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The American Association for the Advancement of Science:
Certain Aspects of Geologic Classifications and Correlations: PROFESSOR ROLLIN T. CHAMBERLIN 183

Obituary:
John Alexander Mathews: PROFESSOR WILLIAM CAMPBELL. *Charles Edward Moldenke* 190

Scientific Events:
The Second International Neurological Congress; The New York University Weather Station; Gift for Support of Dental Research at Yale University; The Cancer Clinic of the Post-Graduate Medical School and Hospital of Columbia University; The Federation of American Societies for Experimental Biology 191

Scientific Notes and News 194

Discussion:
Upthrust—A Geologic Term: PROFESSOR BAILEY WILLIS. *Alterations in the Foundations of the Exact Sciences in Modern Times:* DR. FREDERICK SEITZ. *Further Comments on the Trihydrol Controversy:* DR. T. CUNLIFFE BARNES 197

Scientific Books:
A New Dictionary: DR. H. A. GLEASON. *The Memoirs of a Botanist:* PROFESSOR A. C. NOÉ 201

Report:
Appropriations for Grants-In-Aid by the National Research Council 202

Scientific Apparatus and Laboratory Methods:
Regulating the Flow of Solution for Plant Cultures: PROFESSOR SAM F. TRELEASE and JAMES R. THOMSON. *The Chicago Soil-Nutrient-Temperature Tank:* DR. GEORGE K. K. LINK 204

Special Articles:
The Rôle of the Carbamino Compounds in the Transport of CO_2 by the Blood: DR. WILLIAM C. STADIE. *Refractoriness to Ovarian Stimulation in the Rhesus Monkey:* DR. ROLAND K. MEYER and DR. EDWIN L. GUSTUS. *The Control of Bronchial Asthma:* DR. NOEL F. SHAMBAUGH and SAM M. ALTER 207

Science News 8

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CERTAIN ASPECTS OF GEOLOGIC CLASSIFICATIONS AND CORRELATIONS[1]

By Professor ROLLIN T. CHAMBERLIN

THE UNIVERSITY OF CHICAGO

GENERAL CONCEPTS

OUR knowledge of the history of the earth has been developed gradually by fitting together the histories of small areas studied in detail. As the early geologists gradually became familiar with the rock formations of their own districts, they began to classify the strata in groups. Comparison of individual findings with those of geologists in other areas was particularly stimulating and led to more searching and critical study; correlations between different regions were attempted, and historical geology began to overspread political boundaries. In the course of time the full succession of rock systems came to be recognized and the broader outlines of the geologic history of Europe and North America became established.

Rather notable it was that the rock systems built up from the stratigraphic sequences and fossil peculiarities of Europe were found to be applicable and useful also in North America, though three thousand miles of Atlantic Ocean lay between. Now the same rock systems and corresponding geologic periods do service the world over. Though great variation in local details is manifest, distant regions seem to have enough in common to make possible a general history of the earth in world-terms. Why this is possible, we can now understand.

We know that for long stretches of time the continental land masses have remained relatively free from diastrophic movements of the more declared sort, during which times erosion has lowered the lands and shallow epicontinental seas have spread widely over their reduced surfaces. Part of this spread of the seas has resulted directly from cutting down the lands

[1] Address of the vice-president and chairman of the section on Geology and Geography, American Association for the Advancement of Science, Pittsburgh, December 31, 1934.

and deposition of much of the eroded material in the oceans, thereby displacing an equivalent volume of water and causing a rise of sea-level. However modified in detail by local crustal movements, from which the earth is never free, as well as frequent eustatic fluctuating of sea-level, the general tendency toward continental inundation at such times is world wide. In these seas have accumulated the successions of sedimentary beds which constitute the marine phases of the rock systems. The sedimentary record developed at such times in such seas has, in general, been most nearly complete; it comprises, as a rule, the best-known portions of most rock systems and is most nearly comparable the world over. During these times of extensive transgression of the seas over low-lying continents, the climates have been largely oceanic in nature, mild and equable, and shallow-water marine life has prospered in an expansional phase. The marine faunas have then been as cosmopolitan as such faunas ever are. Consequently, given sufficient short-lived, rapid-traveling species, paleontologic correlations of the strata formed at such times are at their best, and these portions of the general earth story have been put together most correctly.

Had the relatively quiescent conditions of one of these periods been sufficiently quiet and persisted sufficiently long, the land masses would have been base-leveled and eventually submerged beneath ever-spreading seas. But, happily for land life, we find that after a long period of sea transgression, but before complete wearing down of the lands and final submergence was accomplished, a reversal of processes has invariably occurred. Recurring stresses have rejuvenated large portions of the continents and folded certain belts into mountain chains. Like the transgression of the sea, its regression is also far more than a local phenomenon.

We know that the principal belts of mountain building, such as those of the Caledonian, Hercynian, Alpine and Cordilleran orogenies, have been very long, arcuate strips, the last named of which reached fully a third of the way round the globe. Such long, winding belts of earth wrinkling tell of world stresses rather than local stresses, and imply a certain parallelism of major events over large areas. The diastrophic revolutions are thus of more or less cosmopolitan significance.

Very important for our problem, however, is the relation of general continental emergence to the more intensified orogenic earth distortions. It is natural enough to regard both relative uplift of continental areas and the much stronger deformation of particular belts as differently expressed results of the same earth stresses. One phase of this conception is the belief of some geologists that episodes of strong folding are genetically related to sinking of the ocean basins. On this question, however, there is no unanimity of opinion. But, as a rule, we find that general emergent conditions have been an accompaniment of the orogenic revolutions. To the emergences we owe the breaks in the stratigraphic sequence. Furthermore, we recognize that the orogenic revolutions have been characteristically short in duration compared with the times of relative quiescence and extended marine sedimentation. Accepting the generalization that the revolutions are accompanied by general emergences and important interruptions of the marine sedimentary record, they naturally serve as positive beats to mark off the long geologic periods of earth rhythm.

But because of the areal extent of a diastrophic revolution, exactly synchronous earth yielding in different portions of the globe is hardly to be expected. Indeed it would be strange if the resistance of the rocks were overcome at precisely the same time throughout the whole stretch of a major deformation. All the eggs in a nest do not hatch the same day. Although we recognize a general simultaneity, just how nearly synchronous the earth failure has commonly been throughout a belt of deformation is one of the important questions of geologic history, upon which more information is greatly needed. The problem of correlation would be less complex if each diastrophic revolution consisted of but a single pulsation, but instead it commonly consists of several distinct episodes or separate paroxysms of relatively short duration spaced between longer and quieter intervals. The relative intensity of the individual paroxysms may vary from place to place. Viewed in detail the problem of correlation appears very complicated, but viewed in larger units it becomes simpler because in many cases the whole revolution has occupied a span of time much less than that of either the geologic period immediately preceding or that immediately following, and the span of the revolution as a whole has been more or less contemporaneous over the globe.

The consequences of an episode of major deformation are far-reaching. Large areas of epicontinental sea bottom become land; in these marine sedimentation ceases, erosion occurs, and an unconformity eventually results. Climates become more diversified as oceanic conditions give place to continental conditions and severe mountain climates develop locally. Glaciation comes on in the more declared cases and extreme aridity may appear in places. Plants and animals are profoundly influenced by the changing environments. This whole combination of related changes has been attendant upon the diastrophism. In recognition of this, two decades ago, appeared the dictum:

"Diastrophism is the ultimate basis of classification and correlation."

The full accomplishment of these ramifying developments requires, however, a considerable length of time, and the changes do not progress everywhere at the same rate. Such is inevitable in the very nature of the case. Consequently, a close correlation of the individual steps in the progress of events over widely separated areas, while correct in many cases, is manifestly incorrect in other cases. Variability has characterized many of the links in the chain. Although certain changes, or certain steps of advancement, did not take place at the same time in different regions, nevertheless the diastrophic revolution, which inaugurated the changes, is the basic process upon which the rest are dependent. So it is that our geologic periods, though originally established primarily on stratigraphic and paleontologic grounds, are for the most part found to be delimited also by episodes of pronounced diastrophism. Since much of the globe has been involved to some extent in the diastrophism, our present geologic periods and rock systems are also of wide applicability and have become standard over the whole earth. But this does not mean that the future will see no changes in the periods as now outlined; there are not a few infelicities in our present classification; with increasing knowledge and a better understanding of the real significance of a geologic period, it is probable that important improvements will be made. Some of them are perhaps already in sight.

PRE-CAMBRIAN CORRELATIONS

The nebular hypothesis of Laplace gave rise to the very simple picture of a hot molten globe which froze over on the surface and thereby gave rise to an original granitic crust which came to be called the primordial Archean and on which were laid down in succession the later sedimentary deposits. The Archean thus conceived was very clear-cut and definite. Now this distinctiveness has largely disappeared; water-laid sediments are among our oldest rocks, and where to place the upper limit of the Archean has become a matter of pronounced difference of opinion. Sir Charles Lyell's doctrine of uniformitarianism now applies as well to our earliest rock-revealed geologic history as to that of any later time, and if we could decipher the rocks beneath the oldest yet studied who can say that the doctrine would not still apply? The beginning of the familiar geologic processes on the globe is beyond our ken. A pre-Archean rock system is more than a possibility. Viewed in this light, the Archean system takes on a different aspect. Its lower limit must be passed over; but where shall its upper limit be drawn? This question leads to the principles of pre-Cambrian classification and correlation.

The great thicknesses of pre-Cambrian strata, like those of later ages, are naturally grouped into their larger units on the basis of pronounced unconformities. This is a practical procedure because the unconformities make natural divisions. Pre-Cambrian strata are also classified and correlated on the basis of large batholithic intrusions which cut across certain rock groups but do not penetrate other groups. This also is a practical field method of differentiating formations or groups of formations. We therefore ask ourselves: To what extent are time divisions based on granites merely a matter of practical convenience and to what extent do they have fundamental significance? Is there any relation between strong angular unconformities and batholithic intrusions?

For clearer understanding we turn to later and better-known eras of earth evolution. The later diastrophic revolutions reveal a common sequence of events. First is the well-known accumulation of many thousands of feet of sediments in a geosynclinal trough or belt of pronounced sinking. Secondly, after a long period of accumulation these weak sediments are compressed during a very much briefer interval of time into a folded mountain system. During a late stage of the strong folding process, but before the deformation ceases, large masses of acid magma characteristically intrude the heart of the folded mass. The rocks which have participated in the folding are cut across extensively by the invading magma and in places are strongly metamorphosed. Thirdly, the processes of erosion now proceed to reduce the mountains to lowlands; if the reduction goes far enough they uncover the intruded plutonic rocks in the core of the folded belt and they may bring the entire region to the condition of a peneplain. The first and third stages each occupy more time than the second. Subsequently, sedimentary deposits may again be laid upon the site of the former mountain system constituting an entirely new group of rock strata. The new rock system is thus separated from the older system, or systems, by a strong angular unconformity representing a long interval of time during which important events took place in the region.

In this problem the significant feature of the granite is that its injection occurred at the time of mountain-making between the earlier period of sedimentation and the later period of sedimentation. It therefore belongs to a part of the time interval represented by the unconformity between the two sedimentary systems and serves in a positive way to mark that interval. Consequently, a classification on the basis of the granite is essentially the same as a classification based on the unconformity.

The practical value of intruded granites in pre-Cambrian correlation lies in the fact that the batholithic masses are now exposed over considerable areas throughout much of the deeply denuded belt of correlative folding. They can thus be used rather generally along the grain of the folded structure in any one given structural province. Such structural provinces we know to be long in the direction of the axial lines of folding, but as a rule they are much more limited in width across the grain of the region. Recognition of their extent and limits is very important in pre-Cambrian correlations.

For a given province, such as the southern margin of the Canadian Shield, or at least important portions of it, the granite method of classifying rock systems is theoretically sound. In this particular province the three granites of widely different ages, the Laurentian, Algoman and Killarney, are practically and potentially of great assistance in unraveling and delimiting the pre-Cambrian systems. In actual application, however, a serious drawback arises from the fact that in many places, where exposures are limited, the correct identification of a particular granite is very difficult, though probably not beyond solution by our present field methods. The ultimate outcome at any rate looks hopeful.

But when an attempt is made to correlate, for example, the Archean of the southern border of the Canadian Shield with any group of rocks in the Piedmont area of the Atlantic states, the grounds for correlation by our present field methods are extremely insecure. Two different structural provinces are involved and while, according to our general conception, some relationship in the historical sequence of the two provinces is natural, we do not know the extent of such relationship. One or more of the three great pre-Cambrian diastrophic revolutions with batholithic intrusions may have occurred in the Canadian Shield, while only mild manifestations of quite a different sort affected the Appalachian Piedmont. Conversely, strong pre-Cambrian folding may have occurred in the Piedmont at a time when the Shield was but slightly involved. The so-called Archean of the Appalachian Piedmont therefore may, or may not, correspond to the recognized Archean of Lake Superior.

It has been common practise to designate as Archean the extensive granites of the Bighorn Mountains, those of the Front Range of Colorado and those of various other Rocky Mountain ranges. But, as a matter of fact, can we tell whether the granites which underlie the Cambrian sandstones in the Front Range of the Colorado Rockies are correlative of the Laurentian granite of the Canadian Shield, or of the Algoman granite, or of the Killarney granite, or whether they were intruded at some entirely different time or times? In the same way the Vishnu schists in the bottom of the Grand Canyon in Arizona are called Archean. But, after all, do ordinary field studies give us even the basis for a poor guess that these schists are in reality Archean, in the sense of being pre-Laurentian? These several regions lie far apart and apparently are different structural provinces. Similarly, the correlation of the Archean between continents, together with any attempted separation of the pre-Cambrian into Archeozoic and Proterozoic in distant lands on a time basis, faces like uncertainties. Ordinary geologic methods will help solve these problems, but it may be doubted whether they will solve them satisfactorily.

But there is in sight a method which offers good hopes of giving us the desired correlations. That method, apparently our chief hope in long-distance pre-Cambrian correlations, lies in the age determinations of intrusive rocks by measurement of the radioactive disintegration which has taken place within them since they were intruded. Time, measured in years, can be compared directly throughout the extent of the earth's surface. The major intrusions of acidic magma came with the diastrophic revolutions which were critical times of earth history and properly serve to mark off geologic periods. If their ages can be determined with a fair degree of accuracy we are on the road toward a satisfactory classification of the pre-Cambrian and the correlation of its major divisions in different structural provinces and on the different continents in so far as there has been a parallelism of events in the areas considered. Success in discovering the true relations will depend largely upon the accuracy of the time estimates.

How reliable are the radioactive determinations of the ages of intrusive rocks? This question is now being investigated critically by capable chemists and physicists in an effort to iron out the present discrepancies in the results obtained by different lines of attack. Progress seems assured and satisfactory results are apparently to be expected. Professor Lane informs me that in particularly favorable cases, which depend upon minerals high in uranium taken from freshly opened material, the probable error in age determination may be of the order of 5 per cent.

From geologic evidence, the Laurentian, Algoman and Killarney granites appear to be so different in age that radioactive age determinations should distinguish between them. We, therefore, have every reason to expect that identification and correlation on this basis will soon be possible. Such correlation obviously will not stop with the Canadian Shield, but comparisons should be possible with other granites of North America and those of other continents as well. From the granites as time markers, correlations may then be extended with varying degree of certainty to

the associated sedimentary formations. At last we seem to be on the eve of general pre-Cambrian correlations on a basis which invites considerable confidence.

The utility of the method is of course not limited to the pre-Cambrian. Especially useful it should be in bringing the pre-Devonian history of the southern half of Africa into accord with the general history of the rest of the globe. In South Africa the oldest well-preserved fossils occur in Devonian strata; there the expression pre-Devonian has somewhat the same connotation as has pre-Cambrian in other continents; yet South Africa displays many important rock systems older than the Devonian, now known only by local names. Their proper placing in the established periods which do service elsewhere is greatly needed.

We may now return to our earlier question: Where shall the upper limit of the Archean be placed? In the several different positions in the rock column where it is now placed by different geologists we see the diversity of current opinion. For the Canadian Shield the choice lies between the Laurentian revolution and the Algoman revolution. Each has its advocates, and partisanship seems to depend primarily upon the portion of the shield with which the individual is most familiar. Geologists studying the Lake Superior region have been impressed with the great difference between the pre-Laurentian basement complex, which can be unscrambled with great difficulty, and the post-Laurentian metamorphosed sediments to which stratigraphic methods of investigation can be more successfully applied. On the other hand, to geologists working in eastern Ontario and Quebec, the Algoman revolution has seemed to have occasioned a greater break in the rock record than the Laurentian revolution. The question therefore becomes: Which revolution is more important in general earth history?

The secular trend in historical geology is from provincial points of view toward increasing cosmopolitanism as ever-widening areas of the globe are receiving detailed study. Local peculiarities are to be subordinated to those of more general application. In this spirit, though we may prefer one or the other of these revolutions for the close of the Archeozoic, we may well keep a somewhat open mind awaiting comparisons with other important pre-Cambrian areas as better correlations become possible. In the meantime we have Leith's suggestion that time equivalency in the pre-Cambrian be held in abeyance for the present and that instead the basis for the major divisions be rock types, as rocks of the Archean type and rocks of the Algonkian type. This has its uses. But by definition geology is the history of the earth and its inhabitants, and pre-Cambrian history will not be on a satisfactory basis until a fair degree of time equivalency has been established there as in the later history of the globe. Very close time equivalency, however, must not be expected nor implied by pre-Cambrian correlations. Possibly it may prove most practical to divide the pre-Cambrian only into a succession of rock systems and periods without attempting to group these into eras. In any case the large units are systems and not series as some of them are now so commonly called. The Lower Huronian and the Upper Huronian, for example, however they may be named, are each fully comparable to a typical Paleozoic system, either in duration of time, sedimentary successions or according to diastrophic cycles.

The Keweenawan Problem

The divergence of opinion in classifying the Keweenawan system of the Lake Superior region serves to illustrate another phase of the general problem of classification and correlation. Here a succession of lava flows totaling many thousands of feet was followed by waning volcanism and the deposition of a great series of subaerial clastic sediments, interbedded at first with flows, but continuing long after the flows ceased and the more pronounced deformative movements which produced the Lake Superior basin had largely come to an end. In Michigan and Wisconsin this thick succession of terrestrial conglomerates, sandstones and shales has long been known as the Upper Keweenawan. In Minnesota the apparent correlative was designated the Red Clastic series by Hall, Meinzer and Fuller in 1911. Both are overlain by the well-established marine St. Croixan series of the Upper Cambrian. As recently stated by Trowbridge and Atwater, geologists working from the older rocks upward in the stratigraphic column have included all the Keweenawan below the marine St. Croix series in the pre-Cambrian, whereas those working from the Paleozoic downward in the stratigraphic sequence, finding that the undoubted Upper Cambrian sandstones are not set off from the older clastics beneath by any very pronounced break, have not seen sufficient reason for separating the Upper Keweenawan from the Cambrian. Many of the latter have favored placing the Upper Keweenawan in the Cambrian and some have carried the idea further to include the entire Keweenawan in the Paleozoic.

In 1926 Stauffer was fortunate enough to obtain in well cuttings from the upper part of the Red Clastic series of Minnesota a few brachiopods and trilobites which resemble those found in the Middle Cambrian of Montana and Wyoming. The shales in which these fossils occur he confidently referred to the Middle Cambrian. Here indeed was an important step forward. An arm of the Middle Cambrian epiconti-

nental sea, though perhaps only of transient duration, reached Minnesota and by its fossil record has served to date the upper beds of the Red Clastic series. Previous to the arrival of this sea a long period of non-marine deposition is indicated by the main mass of the Red Clastics.

The general picture now becomes clearer. The interval between the Proterozoic and the Paleozoic was characterized by an emergent North America. Late in the Proterozoic (following our present classification) prodigious floods of lava poured into the Lake Superior basin. Gradually the lava outwellings slackened and thousands of feet of continental clastic deposits, derived in part from erosion of the lavas, continued to fill the subsiding basin. Rejuvenation of the waste-supplying areas at the close of the Proterozoic would but increase the supply of detritus and prolong the depositional process. No notable break in the continuity of the series need have occurred. As the processes were entirely continental in nature and dependent largely upon sufficient relief of the land, changes in sea-level far removed from the Lake Superior region had little effect on them. Readvancing seas which started the deposition of the marine Lower Cambrian beds in many other parts of the globe need have caused no appreciable changes in these interior lands. Subaerial denudation and subaerial deposition would continue on during early Cambrian time, subject in general only to those changes which are inherent in the advance of peneplanation. We must recognize that, in such cases, it is entirely natural for provincial continental deposition of a more or less continuous sort to bridge the gaps between periods and even eras. Such linking land deposits have been formed at various times in various parts of the globe, producing a particularly troublesome type of classification problem. Finally the Middle Cambrian seas reached Minnesota and Later Cambrian seas spread over still more of the Lake Superior region. Marine sedimentation succeeded subaerial as the period advanced.

Thus a considerable portion of what has been called Keweenawan seems to have been deposited in Cambrian times. But the early portion of the great Keweenawan succession is very much older and has suffered moderate diastrophism. It is distinctly pre-Cambrian in type, though time classification by types is not necessarily conclusive, since types reveal prevailing conditions with greater certainty than they do specific time. Nevertheless, in the case in hand types do appear significant. We thus seem to have in this Lake Superior continental succession a lithologic record of the long interval between established Proterozoic and recognized Paleozoic of which, thus far, so little has been known. This fact alone adds not a little in interest and importance to further investigation of the various aspects of the problem.

The general nature of what has happened in this region is more or less clear, but for the purposes of classification where is the division between the Keweenawan and the Cambrian to be made? That is one of the immediate objectives. For the next step, however, present information is inadequate. Further directed study is necessary. Provisionally the division between the Keweenawan and the Cambrian may perhaps be placed at some break or pronounced change in the sedimentary sequence. According to Joseph Adler, some possibilities have already been noted in the Keweenaw Peninsula region. Ultimately the division may need to be modified for better accordance with the general diastrophic history of North America just preceding the Cambrian when the nature of the events which took place at that time shall be more fully understood.

The Permian

From the close of the Proterozoic we pass on to the close of the Paleozoic. The Permian is peculiarly the period of problems. Few times in the well-recorded history of the earth have been characterized by such critical happenings as the closing stages of the Paleozoic. Diastrophism of the most pronounced sort, glacial climates of surpassing intensity, an extraordinary development of red beds throughout the globe and profound biologic changes combined in climacteric fashion to make this a time of striking events and difficult problems.

The Hercynian revolution converted large areas of shallow sea into land and uplifted extensive tracts in various parts of the globe into lofty mountains, which together are thought to have been instrumental in bringing on diversified, continental climates of unsurpassed severity which, in turn, apparently led to extinction of many forms of life and a radical modification of others to meet the altered conditions. This chain of consequences was of a far-reaching sort, and the full sequence of events occupied a long time. The changes were slow in the aggregate, though profound. They came to be strongly in evidence in Pennsylvanian time and lasted in milder form into the Triassic. The intervening time during which these interrelated events took place is the Permian or Permo-Carboniferous. It was emphatically a time of transition, from the mid-Pennsylvanian to the Triassic, from the Paleozoic to the Mesozoic, from ancient to medieval life.

Shall this long time of transition be considered a regular geologic period, and, if so, shall it be placed in the Paleozoic or in the Mesozoic? If not an independent period, shall it be added to the Carboniferous or to the Triassic, or shall it be divided between them?

Questions such as these have been arising in the minds of geologists for some time and have led recently to a symposium before Section C of the British Association at the Bristol meeting on the validity of the Permian as a system, and to another discussion of the same general problem at the Sixteenth International Geological Congress in Washington. The diversity of expressed opinion has been very great. Some of the elements considered have been: The length of time represented; the evolutionary changes; distinctiveness of the fauna and flora; general usefulness and practical convenience; adherence to the original definition; redefinition on the basis of marine invertebrates; the break within the Rothliegende; possible fixing of limits according to episodes of the Hercynian revolution, etc. Including the Permian in the Carboniferous, it has been thought, would make that system too cumbrous; putting the Permian and Triassic together would make that system too unwieldy. Some students have favored partition of the present Permian; but most of those who have expressed views have preferred retention of the Permian in some form. In general the discussions from the standpoint of the practical stratigrapher have been thorough. The broader philosophical aspects of the problem, however, have received rather less consideration.

Geologic thought has now progressed to the point where the larger implications of the earth's past record are becoming clearer and more essential in an adequate understanding of the earth drama. It is now coming to be generally recognized that the Hercynian revolution in the Pennsylvanian, followed by extraordinary glacial climates and marked aridity in the later Pennsylvanian and Permian, was of great importance in bringing on the change from ancient life to medieval life. Obviously the biologic response to these exceptional physical conditions is rightly to be regarded as of prime consequence, but is it, after all, of greater importance than the chain of physical events which caused it? The more distinctive repression of the old order of life and rise of the new apparently started with one of the strong episodes of Hercynian deformation and the adverse climates. Inevitably, however, the process of elimination and readjustment extended through a considerable span of time. There were also further episodes of deformation with attendant consequences. Some forms of life disappeared early; other forms persisted longer; new forms, born of adversity in its varying degrees, came on the scene at different times and in different places.

Where to draw the line of division between the Paleozoic and the Mesozoic therefore involves the general question: Shall the new era commence with the most pronounced expression of the underlying physical phenomena and the beginning (or an early stage) of the biologic response, or shall it start only when the biologic response has progressed so far that the fauna and flora have become radically different from those which preceded? Shall the chain of transitional events be hooked on to the previous era as its dying phase, or shall it belong to the new era as its inauguration? Or shall it be divided between them? Whichever alternative we work toward, it is essential that we recognize properly the diverse elements involved in a satisfactory solution of the problem.

The appearance of new forms of life is generally regarded by paleontologists as of greater significance than the disappearance of lingering forms of old life. Viewing the problem in this light, we should naturally be inclined toward moving classification boundaries forward, or earlier in time, rather than in the reverse direction. In the present case this is toward the onset of the pronounced changes in physical environment which were seemingly so important in influencing the evolutionary progress among plants and animals. If we are correct in tracing the remarkable succession of physical changes of the Permian back to the exceptional display of diastrophism we naturally look to the diastrophism as the primary control.

But the problem is not simple. The diastrophism during this transitional time was episodic in character, recurring in several separate spasms. At the close of the Mississippian period occurred the Culmide disturbance which serves to divide the Carboniferous into Mississippian and Pennsylvanian. In Europe this has been termed the Sudetic deformation for, between the Dinantian and Middle Carboniferous, there was strong folding from the Vosges Mountains to the Sudetes. The importance of this division of geologic time is becoming increasingly apparent. It may be noted in passing that David and Süssmilch believe that the first of the late Paleozoic glaciations of Eastern Australia, which follows the Wallarobba (Culmide) disturbance, took place at about this time.

Particularly prominent also was the Asturian phase of the Hercynian revolution, occurring between the Westphalian and Stephanian epochs of Western Europe, or the Moscovian and Uralian of Eastern Europe. At that time arose great mountain chains across much of Central and Southern Europe and apparently South Central Asia as well. In this country strong deformation occurred in the Wichita-Arbuckle-Ouachita region, in the so-called Ancestral Rockies, and probably also in portions of the Appalachian system, approximately correlative with the European deformation.

Considerably later, following the Autunian (Lower

Rothliegende) came the Saalian deformative episode, notably in Central Europe, the Eastern Alps and the Ural Mountains. Extensive unconformities and important floral changes were associated with this episode. After the Dunkard, though we do not know just how soon after, was the main Appalachian revolution in the Eastern United States. This may well have been contemporaneous with the Saalian diastrophism of Europe, but the correlation has not been definitely established.

At the close of the Permian, as now delimited, came the Pfalzian episode of Stille in the Palatinate of Germany, and some neighboring areas. This diastrophic manifestation was feebler and more local than the others just mentioned.

(To be concluded)

OBITUARY

JOHN ALEXANDER MATHEWS

JOHN ALEXANDER MATHEWS died suddenly of a heart attack on January 11, 1935, at his home in Scarsdale. At the time of his death he was vice-president and director of research of the Crucible Steel Company of America and a metallurgist of world-wide repute.

For over thirty years he was in the first rank of American steel metallurgists and among his most notable achievements were the use of the electric furnace in the quantity manufacture of high quality steel, the improvement of high speed steel by the addition of vanadium in 1903 (Rex AA) whereby its cutting efficiency was trebled, the development of various vanadium steels, especially spring steels, and of oil-hardening magnet steels of chrome vanadium, and of corrosion- and heat-resisting steels and the so-called stainless steels.

Born at Washington, Pa., May 20, 1872, he took his B.S. degree at Washington and Jefferson College in 1893 and M.S. in 1896. Coming to Columbia University he obtained his A.M. in chemistry in 1895 and his Ph.D. in 1898. After instructing in the chemical department at Columbia for two years he was given the Barnard fellowship and with it went to the Royal School of Mines, London, in 1900, to study metallography under Sir William Roberts-Austen. It was there I first met him; we were the only two graduate students that year, had adjoining benches and were soon very good friends, for no one could resist his kindly and friendly manner and good fellowship; in fact, all the students in metallurgy used to drift over to his desk to hear about the States. Roberts-Austen thought so highly of him that he strongly recommended Mathews for one of the first Carnegie Scholarships of the British Iron and Steel Institute, which he received. Returning to Columbia in the fall of 1901 with me in tow, we worked in Henry Marion Howe's laboratory in the basement of Havemeyer Hall, Mathews on a series of alloy steels which were made for him at the Sanderson Steel Company at Syracuse, myself continuing the work I had begun with Roberts-Austen on the bronzes at the next bench. His report on this work was awarded the first Carnegie Gold Medal by the Iron and Steel Institute. Finishing this work he went to the Sanderson Brothers Steel Company, Syracuse, as metallurgist in 1902 and soon became assistant manager. From there he went in 1908 to the Halcomb Steel Company, Syracuse, of which he was operating manager and in 1913 president and general manager until 1920, when he became president of the Crucible Steel Company of America. Three years of being a president of a steel company was enough for any real scientist and so in 1923 he was promoted to what he considered a really satisfactory job, namely vice-president and director of research.

He served on numerous technical committees, notably that on aircraft engine forgings of the Bureau of Aircraft Production during the war, was for some time chairman of the Iron and Steel Committee of the American Institute of Mining Engineers, and of the Committee on Alloy Steels of the National Research Council, and did notable work on various committees of the Society for Testing Materials, etc. He was also a member of the Columbia School of Mines Advisory Committee and for several years gave an annual lecture to the pre-engineering class.

He was a clear, concise writer and published about 100 papers, chiefly on the constitution and properties of alloy steels. His worth was recognized by his associates. He received the Carnegie Gold Medal from the British Iron and Steel Institute in 1902, from Washington and Jefferson the honorary Sc.D. in 1903, the Hunt Gold Medal from the American Institute of Mining and Metallurgical Engineers in 1928, and was an honorary member of the American Society of Steel Treaters (now the American Society of Metals). In 1924 he was appointed the second Henry Marion Howe lecturer of the American Institute of Mining Engineers, succeeding Professor Albert Sauveur of Harvard.

It is so easy to tell what a man has done, to list his honors and publications, but how difficult to put in words what he really was. To those who knew him in public or private life or worked with him on committees or in the works that is not necessary, for his kindly personality and the charm of his company

endeared him to all. His friends will miss him, but more lasting will be the loss to those young men who grew up under him, either in the laboratory or in the plant, engaged in research or production, for in him they always had a real friend, who combined those rare qualities of leadership in both the practical and the scientific side of their work, of a patient teacher and a reliable guide. It is to such men we can give the title of a kindly gentleman.

WILLIAM CAMPBELL

COLUMBIA UNIVERSITY

CHARLES EDWARD MOLDENKE

DR. CHARLES EDWARD MOLDENKE, born on October 10, 1860, at Lyck, East Prussia, died at his home in Watchung, N. J., on January 18. Dr. Moldenke received his B.A. and M.A. degrees from Columbia University and his Ph.D. from the University of Strassburg. He was widely known as a student of classical archeology, antiquities and history and was a philologist of the first rank, master of 19 languages, including Hebrew, Arabic, Sanskrit, Icelandic, Anglo-Saxon, Pehlevi, Hieroglyphic, Hieratic, Demotic, Coptic, Cuneiform and Persian. His fame as an Egyptologist was world-wide. He was the first to translate the inscriptions on the New York Obelisk in Central Park and was the author of seven books on Egyptian subjects.

Having extensively traveled throughout Europe, Asia Minor, northern Africa and many parts of the Americas, his interest soon turned to the wonders of nature. Becoming a diligent student of botany, he became an indefatigable collector, not only of antiquities, but also of plant specimens. In 1886 he published an important work on the trees of ancient Egypt, bringing together for the first time all available information about the trees cultivated by the ancient Egyptians, including their origin, uses and names. In 1911 he traveled and collected in Cuba, Puerto Rico, St. Thomas, Jamaica, Panamá and Venezuela, and in 1916 and 1927 in New England, northern New York and Pennsylvania. In 1929–1930, accompanied by his younger son, he botanized throughout the southeastern states, spending six full months in Florida alone, which he traversed from end to end, paying special attention to the flora of the everglades, subtropical hammocks and the keys. Over 23,000 plant specimens were collected on this trip alone. In 1932 he made a circular tour of the entire United States, visiting every major phytogeographic province and making excellent and thorough collections of the representative flora of each province. In 1933 he botanized through the Middle West, the badlands of South Dakota and the Black Hills, and in 1934 visited again the rich collecting grounds of Kentucky, Arkansas, Oklahoma, Texas and Louisiana. Including the many plants brought back by him from his European, Oriental and African travels, Dr. Moldenke collected over 50,000 plant specimens, the majority of which are now deposited in 30 of the leading herbaria of the Old and New World and the remainder now being assembled into sets for distribution by his son, an assistant curator at the New York Botanical Garden.

CORRESPONDENT

SCIENTIFIC EVENTS

THE SECOND INTERNATIONAL NEUROLOGICAL CONGRESS

THE second International Neurological Congress will be held in London from July 29 to August 2, under the presidency of Dr. Gordon Holmes. At the program executive conference held in London in 1933 Sir Charles Sherrington was elected president by the assembled delegates, but since then he has been compelled to resign on grounds of health. According to the *British Medical Journal*, the various sessions of the congress will be held in the large hall of University College, Gower Street, W.C. 1, and in lecture rooms of the college. After the official opening on July 29, Professor O. Marburg will preside over a discussion on the epilepsies, their etiology, pathogenesis and treatment, and this will be continued in the afternoon under the chairmanship of Professor O. Rossi. The morning of July 30 will be devoted to a discussion of the physiology and pathology of the cerebro-spinal fluid, under the chairmanship of Professor O. Foerster, and miscellaneous papers will be read in the afternoon. On August 1 Professor H. Claude will preside over a discussion of the functions of the frontal lobe, and on the morning of August 2 the hypothalamus and the central representation of the autonomic system will be considered under the chairmanship of Professor H. Brouwer. The afternoons will be occupied with the reading of miscellaneous papers. The number of these afternoon sessions will be determined by the total number of papers offered and accepted; so far as proves practicable, the papers will be grouped systematically under different headings. In the evening at eight-thirty the triennial Hughlings Jackson memorial lecture, under the auspices of the section of neurology of the Royal Society of Medicine, will be delivered by Professor O. Foerster, of Breslau.

The program committee is composed of the British

officers of the congress and the above-named chairmen of the morning discussions, with Dr. S. A. Kinnier Wilson as its secretary. Abstracts of each paper to be read at the morning sessions must be submitted to one of these chairmen or the program committee not later than March 1, by which time also the completed papers must be in possession of the committee. The abstracts must be written in English, French or German. As regards the afternoon sessions, not more than one paper from any one member of the congress is permitted, but members may take part in any discussion which arises from any paper. All neurologists, neuro-surgeons, psychiatrists and any physicians or surgeons interested in neurology may become active members, the fee being £1 10s. Applications for membership should be addressed to Dr. Kinnier Wilson, 14, Harley Street, W.1, London, or through one of the national committees. The social events and excursions arranged so far include an official reception on the first evening; receptions by the Royal Colleges of Physicians and Surgeons on the second evening; the official banquet on August 1, at 7:30 P. M.; a reception on August 2 in the evening by the section of neurology of the Royal Society of Medicine; and visits to Oxford, Cambridge, Stratford-on-Avon, Windsor and Goodwood.

THE NEW YORK UNIVERSITY WEATHER STATION

THE establishment of a weather station by the New York University College of Enginering, equipped for both ground and upper air observations, on the University Heights campus, has been announced.

The new station, the first meteorological observatory in uptown New York, will be under the direction of Dr. J. Edmund Woodman, professor of geology and lecturer on aeronautical meteorology and navigation at the Guggenheim school of aeronautics at the university.

Weather reports will be made twice daily both to the U. S. Weather Bureau in the Whitehall Building and to the Airway Weather Bureau station at the Newark airport. The station has been named as one of a dozen "special" stations reporting directly to the New York office of the Weather Bureau, and as the first cooperative upper air station in the country. The observatory apparatus has been placed on the roof and in the tower of Graduate Hall on the University Heights campus, and will be available as an instructional laboratory for students of meteorology. Graduate Hall, once the residence of the late Chancellor Henry Mitchell MacCracken, is modeled after New England seacoast homes and is surmounted by a glass-enclosed lookout tower, which should be ideal for the weather recording apparatus.

Pilot balloons will be sent aloft in time for observations to be phoned at 8 A. M. and 8 P. M. daily, for observations in the upper air. The balloons, about three feet in diameter, are inflated with carefully measured quantities of hydrogen just before use so as to give them a known ascensional rate of 600 feet per minute. After release the balloons are observed through a theodolite, an instrument resembling a surveyor's transit, and a record is made of the balloon's position each minute it is visible. For night observations the balloon is made visible by attaching to it a small Chinese lantern lighted by a paraffin candle.

Instruments which will be placed on the roof of the new observatory will include a nephoscope for determining the direction, velocity and disintegration of clouds at various levels; an airways anemometer and anemoscope to give instantaneous readings of wind direction and velocity; an anemoscope and anemograph to give a continuous two-day record of wind direction and velocity; maximum and minimum thermometers; sun thermometers, and a rain gauge.

An instrument shelter just constructed will house a thermograph to give a continuous record of temperature; a whirling psychrometer to give relative humidity and rate of evaporation; and a hair hygrometer to give a continuous record of humidity.

Inside the tower of the observatory there will be a mercurial barometer and a microbarograph and a battery of aneroid barometers for determining atmospheric pressures; a battery of accurate Centigrade and Fahrenheit thermometers; anemograph and airways indicators for determining wind velocity and direction; a hygrodeik for determining relative humidity; several sling psychrometers; plotting boards and other weather instruments. The station will have a meteorological library and facilities for research.

GIFT FOR SUPPORT OF DENTAL RESEARCH AT YALE UNIVERSITY

A GRANT of $17,500 has been made by the Carnegie Corporation of New York to Yale University for the support of dental research in the School of Medicine during the coming year, according to an announcement made by President James Rowland Angell. This gift makes possible the continuance of a program launched six years ago to promote the scientific study of the teeth and to stimulate the interest of physicians in the rôle played by the teeth in health and disease.

The dental research project at Yale is unusual in many ways and has been watched with interest from its inception by both the dental and medical professions. It is one of the few organized attempts to enlist medical personnel and resources in the study of dental problems and to provide a full medical train-

ing for a group of men fundamentally interested in the teeth.

The program of the school does not call for the development of a training center for dentists. The aim is not to supplant dentists by physicians or to replace dental with medical education. The purpose in the first place is to increase knowledge of the teeth, their development, and the diseases to which they are subject; and secondly, to establish a closer relationship between dentistry and medicine so that each field can benefit from the other. A small group of men are being given the opportunity to become highly skilled in dentistry and medicine in order to conduct research and to establish a link between these two related sciences.

The study group consists of members of various departments in the School of Medicine, a dentist who is on the full-time teaching staff of the school, and a small number of recent graduates of dental schools, selected on the basis of skill and scientific interest in the care and study of the teeth. Two graduate dentists have been admitted each year to the regular course in medicine. In addition to studying medicine, they engage in research on dental problems under the supervision of staff members, and assist in providing dental service for patients in the dispensary and hospital.

Progress along various research lines has been made by the dental study group. Among the benefits of the program, in addition to the results of research, are cited the increasing recognition in the medical school of the importance of the teeth and the growing interest in them as a subject of study; improvement in the care of hospital and dispensary patients because of the consideration given to the condition of the teeth; and the general stimulus given to dental research and education.

The interest of a group of New Haven dentists in the project as a whole has been demonstrated by the formation of the Dental Clinic Society which provides over 500 treatments monthly for indigent patients. The society has its own professional staff, but is conducted in close cooperation with the dental study group and community social agencies.

THE CANCER CLINIC OF THE POST-GRADUATE MEDICAL SCHOOL AND HOSPITAL OF COLUMBIA UNIVERSITY

A LARGE and completely equipped clinic for cancer and skin diseases, which is prepared to give 200,000 treatments a year, was opened recently in the New York Skin and Cancer Unit of the Post-Graduate Medical School and Hospital of Columbia University, according to the New York *Herald-Tribune*. The new clinic was formed by the affiliation of the Stuyvesant Square Hospital, better known as the New York Skin and Cancer Hospital, with the Post-Graduate School last autumn. It combines the out-patient services of the departments of dermatology and syphilology of the two hospitals and occupies the entire four-story building which formerly housed both the in- and out-patient services of Stuyvesant Square Hospital.

It is believed that the new clinic will rival the dermatological centers of Europe. There will be a staff of eighty physicians and technicians, with administrative offices, social service, pharmacy, x-ray and photographic departments, and every facility for the examination of patients and the investigation and modern treatment of disease. There are several laboratories, with ample facilities for clinical and laboratory research, as well as operating rooms for minor surgery and biopsies and demonstration and lecture rooms.

An important possession of the clinic is approximately 1,200 milligrams of radium, valued at $77,958. The radium treatment of disease will continue under the same procedure as before affiliation, the only change being that the treatment of general cancer cases has been taken over by the Post-Graduate Hospital, which cares for all hospital patients. For this reason the radium, formerly the possession of the Stuyvesant Square Hospital, has been transferred to the department of radiology of the Post-Graduate Hospital, so as to be available to all departments of both institutions. The clinic is open daily, except Sundays and holidays, with morning and afternoon sessions.

Both institutions have carried on considerable research work. In the new clinic the field will be covered by research in immunology, mycology, histopathology, physics, x-ray and radium, biospectrometry, bio-chemistry and cancer research. In time the new institution should rank with such centers of teaching and research as the St. Louis Hospital in Paris, Pautrier's Clinic at the University of Strasbourg, the University of Zurich Clinic in Switzerland and the Breslau Clinic, which was formerly under Jadassohn's direction.

Both hospitals were founded in 1882, and each was a pioneer in its respective field, the Stuyvesant Square Hospital being the oldest cancer hospital in America, and the Post-Graduate Hospital the first exclusively graduate school of medicine in the world.

THE FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY

THE Federation of American Societies for Experimental Biology will meet in Detroit, Michigan, from April 10 to 13, inclusive.

Members who can do so will doubtless wish to continue the practise of arriving one day in advance of the formal sessions in order to devote that day, which

this year falls on Wednesday, April 10, to visiting laboratories, informal social gatherings and discussions.

The Hotel Statler will serve as headquarters. All scientific sessions, except the demonstrations on Friday afternoon, April 12, will be held in the Masonic Temple. The demonstrations will be given in the School of Nursing and Hygiene of the Henry Ford Hospital. The Masonic Temple is within walking distance of the Hotel Statler. Special bus service will also be provided. The program is as follows:

On April 10, there will be held meetings of the executive committee of the federation and of the councils of the societies and the annual meeting of the American Institute of Nutrition at the Masonic Temple. The laboratories of the following Detroit institutions will hold open house for the federation on Wednesday and during the remainder of the week: The Henry Ford Hospital, Grand Boulevard and Hamilton Avenue; The Children's Fund of Michigan, 660 Frederick Street; The Wayne University College of Medicine, 1521 St. Antoine Street; Parke Davis and Company, foot of McDougall Avenue; Frederick Stearns and Company, 6533 E. Jefferson Avenue.

On Thursday, April 11, there will be scientific sessions of the societies in the morning, and in the afternoon scientific and business sessions of the societies will be held.

On Friday, April 12, scientific and business sessions of the societies will be held in the morning and joint demonstrations in the School of Nursing and Hygiene of the Henry Ford Hospital will be shown in the afternoon. Tea will be served later in the Clara Ford Nurses' Home. In the evening the annual dinner of the federation will be in the grand ballroom of the Hotel Statler.

On Saturday, April 13, the scientific sessions of the societies will be concluded. In the afternoon there will be a joint session of the federation.

There will be a special registration and information bureau which will be located on the mezzanine floor of the Hotel Statler.

A reduced fare on the "Certificate Plan" of one and one third fares for the round trip to and from Detroit will apply to members and associate members of the Federation of American Societies for Experimental Biology (and their dependent families).

The local committee in charge of arrangements consists of Dr. F. W. Hartman, *chairman;* Dr. Icie G. Macy, *secretary;* Dr. Oliver Kamm, Dr. Thomas L. Patterson, Dr. O. M. Gruhzit, Dr. O. H. Gaebler, Dr. Arthur D. Emmett, Dr. Arthur W. Dox, Dr. Daniel A. McGinty, Dr. Melville Sahyun, Dr. Nelles B. Laughton. Further information about the meeting can be obtained through Dr. H. A. Mattill, *secretary,* The State University of Iowa, Iowa City, Iowa.

SCIENTIFIC NOTES AND NEWS

DR. LAFAYETTE B. MENDEL, Sterling professor of physiological chemistry at Yale University, has been awarded the Conne Medal of the New York Chemists Club for 1934 for his "outstanding chemical contributions to medicine."

THE 1934 Lamme Medal of the American Institute of Electrical Engineers has been awarded to Henry E. Warren, president of the Warren Telechron Company, Ashland, Mass., "for outstanding contributions to the development of electric clocks and means for controlling central station frequencies." The medal will be presented to Mr. Warren at the summer meeting of the institute, which will be held at Cornell University from June 24 to 28.

DR. WILLIAM P. MURPHY, of the Harvard Medical School and the Peter Bent Brigham Hospital, has been awarded the Order of the White Rose by the President of Finland with the rating of Commander of the First Rank. He was also made a member in December, 1934, of the Kaiserlich. Leopold.-Carolin. Deutsche Akademie der Naturforscher.

PROFESSOR FRANK D. ADAMS, of McGill University, has been elected a foreign member of the Royal Swedish Academy of Science, and an honorary member of the Academia Asiatica of Teheran, Persia.

SIR GEORGE SEATON BUCHANAN, senior medical officer of the British Ministry of Health, was presented on January 25 with the Jenner Medal of the Royal Society of Medicine.

THE Progress Medal of the Royal Photographic Society of Great Britain has been awarded to Harold Dennis Taylor, in recognition of his inventions, research and publication in optical science, which have resulted in important advances in the construction of photographic lenses and in the development of photography.

PROFESSOR A. VON EISELBERG, president of the Medical Society of Vienna, has been nominated doctor *honoris causa* of the University of Paris.

DR. THOMAS BARBOUR, professor of zoology at Harvard University and director of the Museum of Comparative Zoology and the University Museum, has been elected a member of the board of trustees of the Carnegie Institution of Washington.

DR. P. W. WHITING will have charge of the work in genetics during the present term at the University

of Pennsylvania, where he is a guest lecturer in zoology.

DR. HOWARD WALTER FLOREY, of Magdalen College of the University of Oxford, has been appointed professor of pathology.

DR. LEO ROGIN, lecturer in economics at the University of California, who has been acting chief of the food products division of the Labor Advisory Board, has been made chief of the division.

DR. H. J. FRASER, of the department of geological research of the International Nickel Company, Ltd., is spending some months in the laboratory of Dr. L. C. Graton, professor of mining geology at Harvard University, on special microscopical investigations of the Sudbury ores.

DR. ALBERT F. BLAKESLEE, acting director of the department of genetics of the Carnegie Institution of Washington at Cold Spring Harbor, was elected on January 28 a corresponding member of the Academy of Sciences of the Institute of France. He takes the place in the section of botany made vacant by the death of Professor Chodat, of the University of Geneva. The other foreign correspondents in the botanical section are Professor Ikeno of Japan and Professor De Vries of Holland. According to the last published records, the correspondents in this country from the other biological sections of the French Academy are the following: Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research, Dr. Simon Flexner, director of the Rockefeller Institute, and Professor T. H. Morgan, of the California Institute of Technology and research associate of the Carnegie Institution of Washington.

ALFRED KNIGHT, fellow of the Royal Astronomical Society and formerly vice-president of the Fleischmann Company, was elected president of the American Institute of the City of New York on February 14. The other officers elected were Dr. Oscar Riddle, *vice-president;* L. W. Hutchins, *secretary,* and H. T. Newcomb, ***treasurer.***

DR. CHARLES E. DECKER, professor of geology at the University of Oklahoma, has been elected president of the Oklahoma Academy of Sciences.

AT its meeting on February 6, the executive committee of the American Geophysical Union appointed a special committee on continents and continental evolution as follows: W. T. Thom, Jr. (*chairman*), L. H. Adams, N. L. Bowen, W. Bowie, R. T. Chamberlin, E. Cloos, M. Ewing, R. M. Field, J. A. Fleming, W. R. Gregg, B. Gutenberg, N. H. Heck, M. K. Hubbert, E. S. Larsen, F. W. Lee, L. D. Leet, J. B. Macelwane, L. B. Slichter and H. R. Wanless. The object of this committee is to apply geophysical methods and technique to the solution of the geological problems of continental genesis and evolution, and its work will integrate closely with that of the union's special committee on geophysical and geological study of oceanic basins. The special committee on continents and continental evolution therefore includes men from the following fields: Chamberlin, structural geology; Wanless, stratigraphic geology; Field, particularly because of his chairmanship of the special committee on geophysical and geological study of oceanic basins; Larsen, volcanology; Cloos, Ewing, Hubbert, Lee, Leet, Slichter and Thom, general geophysics and applications to geology; Bowen, geochemistry; Adams, physics of rocks; Bowie, gravity and isostasy; Gutenberg and Macelwane, seismology; Heck, seismology and terrestrial magnetism; Fleming, terrestrial magnetism and electricity; Gregg, meteorology. The union feels that the simultaneous application of geophysics and geology in an attack upon the major problems of earth composition and evolution can not fail to lead to great advances in earth science.

THE George Fisher Baker non-resident lecturer in chemistry at Cornell University for the second term of the academic year, 1934–35, will be Professor Farrington Daniels, professor of chemistry at the University of Wisconsin. His lectures on "Chemical Kinetics" will be given in Baker Laboratory on Tuesdays and Thursdays at 12 o'clock.

PROFESSOR E. WIGNER, of Princeton University, addressed the Physics Colloquium of the University of Pennsylvania on the subject of "Free Electrons and the Metallic Bond" on January 24.

DR. WILLIAM K. GREGORY, professor of paleontology at Columbia University and curator of comparative and human anatomy at the American Museum of Natural History, delivered a lecture entitled "The Study of Human Evolution: A Plea for a More Synthetic Approach" before the University of Maryland Biological Society in Baltimore on January 29.

DR. SAMUEL ALFRED MITCHELL, director of the Leander McCormick Observatory of the University of Virginia, will give an illustrated lecture on "Solar Eclipse Problems" at the meeting of the American Philosophical Society on March 1.

PROFESSOR ARTHUR B. RECKNAGEL, professor of forestry at Cornell University, spoke before the Canadian Society of Forest Engineers at the University of Toronto on January 21 on "Applied Forest Management under the Lumber Code in the Northern States." On January 25 he read a paper on "American Conservation Measures and Rules of Forest Practice" at a meeting of the Canadian Pulp and Paper Association in Montreal.

DR. GUSTAV EGLOFF recently gave a series of lectures as follows: On January 17, before the Northwest Petroleum Association in Minneapolis, on "Modern Products from Petroleum"; on February 7, at a conference on fuel oil and oil burners at the University of Wisconsin, on "Production, Competitive Uses and Future Supply of Fuel Oil"; on February 7, at a meeting of the Northeast Wisconsin section of the American Chemical Society, on "The Cracking Process and Its Products"; on February 14, before the Ohio Petroleum Marketers Association, Inc., Columbus, Ohio, on "Modern Gasoline and Lubricants."

DR. WOLFGANG KÖHLER, professor of psychology at the University of Berlin, lectured on the subject, "Biology and Physics," before the Rutgers University chapter of the Sigma Xi on January 21.

ON January 17, Dr. James E. Ackert, dean of the division of graduate study and professor of zoology at the Kansas State College, addressed the University of Kansas chapter of Sigma Xi on the subject, "Host Resistance to Parasitism."

JAMES I. HAMBLETON, of the Bee Culture Laboratory of the U. S. Department of Agriculture, and Dr. Ronald Bamford, of the department of botany of the University of Maryland, have been recent speakers before the Western Maryland College chapter of Beta Beta Beta. Mr. Hambleton spoke on November 27 on "The Bee as a Honey-maker," and Dr. Bamford on January 29 on "Some Chromosome Problems."

FRANS BLOM, director of the department of middle American research at Tulane University, left on February 12 on an archeological expedition to Honduras. He was accompanied by Jens Yde, of the Danish National Museum.

DR. ARTHUR A. ALLEN, professor of ornithology at Cornell University, on February 13 left for an expedition through the South and West to record and study bird songs. The expedition is under the auspices of the American Museum of Natural History and Cornell University and will be in the field until August 1.

MEMBERS of the committee appointed to organize the celebration of the three hundredth anniversary of the founding of the chemical industry in America, to be held in connection with the meeting of the American Chemical Society in New York from April 22 to April 26, are: Dr. Francis P. Garvan, president of the Chemical Foundation, *honorary chairman;* Dr. Arthur W. Hixson, professor of engineering at Columbia University, *general chairman;* Dr. Lawrence W. Bass, director of research of the Borden Company, New York, N. Y., *vice-chairman;* Dr. D. P. Morgan, chemical economist of Scudder, Stevens and Clark, New York, N. Y., *secretary-treasurer.*

WILLIAM H. TYERYAR, of Frederick, Maryland, has contributed to the Western Maryland College his collection of butterflies and moths, containing over 2,000 specimens, all caught in Frederick and Carroll counties, Maryland.

A GRADUATE of the University of Kansas, whose name is withheld, has recently given $60,000 for the construction of the first unit of a Children's Hospital for the Kansas University School of Medicine. Construction will begin at once.

COLUMBIA UNIVERSITY has announced the following gifts: $5,300 from the Josiah Macy, Jr., Foundation for work in pathology; $3,150 from E. R. Squibb and Sons for fellowships in the departments of biological chemistry and anatomy; $2,000 from the Emergency Committee in Aid of Displaced German Scholars for the salaries of visiting scholars; and $1,500 from Mrs. Elsie Clews Parsons for research in anthropology.

A NEW quarterly, devoted to the publication of mathematical research and sponsored by Duke University, will appear shortly under the title *Duke Mathematical Journal.* The editors are A. B. Coble, University of Illinois; D. V. Widder, Harvard University; and J. M. Thomas, Duke University, the last named being managing editor. The associate editors are H. E. Bray, L. W. Cohen, L. R. Ford, J. J. Gergen, R. E. Langer, C. C. MacDuffee, J. A. Shohat and G. T. Whyburn. The first number will be dated March, 1935.

THE National Research Council announces that a limited number of fellowships in the physical sciences, namely, physics, chemistry, astronomy and mathematics, will be available for use during 1935–1936. Applications must be filed on or before March 1, on forms obtainable from the secretary of the fellowship board in physics, chemistry and mathematics of the National Research Council. A year-book describing the fellowships, stipends, conditions and tenure may be obtained upon application to the secretary.

AN enlarged program of teaching and research in mathematical statistics is being undertaken at Columbia University this year. Research under the auspices of the Carnegie Corporation is being conducted with Professor Harold Hotelling as director, with a view to clarifying the foundations of statistical methods and extending their scope, and particularly in the development of tests of significance and criteria of accurate estimation. For this work Dr. Joseph L. Doob has been appointed research associate, and Margaret H. Richards and William G. Madow research assistants. Professor Felix Bernstein, founder and formerly

head of the Göttingen Institute of Mathematical Statistics, is at Columbia this year as visiting professor of mathematics. A course of training in mathematical statistics has been arranged by the coordination of courses in the departments of mathematics, economics and astronomy to dovetail together without overlapping. This work is designed for students familiar with calculus and higher algebra. It includes probability, taught by B. O. Koopman; statistical inference, by Harold Hotelling; mathematics of heredity and evolution, by Felix Bernstein; training in the use of card-tabulating and calculating machines, interpolation and finite differences, by W. J. Eckert; mathematical economics, by Harold Hotelling, and a seminar in advanced mathematical statistics. In addition there are at Columbia University numerous other courses in statistics designed for students in particular fields.

WE learn from the Associated Press that the Haskell Laboratory of Industrial Toxicology has been established by E. I. du Pont de Nemours and Company. The laboratory was opened on January 22 on the grounds of the experimental station of the company near Wilmington. The new laboratory has been established because of the growth of the chemical industry in this country. It will be housed in a three-story building planned in thirty units, and has been named for Vice-President Harry G. Haskell. The function of the laboratory will be to study the effects of new products upon the health of employees during manufacture, and, prior to these new products being placed on the market, to study their possible effects on public health. Dedication of the laboratory took the form of a scientific meeting presided over by Frank C. Evans, director of the service department of the du Pont company.

DISCUSSION

UPTHRUST—A GEOLOGIC TERM

IN a recent, discriminating review of "Geologic Structures,"[1] the reviewer unwittingly gave the senior author of that manual special satisfaction by singling out for commendation certain chapters written by the junior author, but he also criticized a lack of definition in the use of the term *upthrust,* for which the senior is responsible. Webster gives the definition: "Upthrust, n. An upward thrust; specif. Geol., an uplift of part of the earth's crust." That might be regarded as adequate, but the writer has allowed the word a certain freedom to be verb or adjective, as well as noun. He has designated an upthrust mountain, the Sierra Nevada of California, for instance, an upthrust. The fault which characterizes its eastern face he has called an upthrust fault or an upthrust in that connotation. He might refer to the movement itself as an upthrust or upthrusting. And he would defend each of these uses or any others in which the connection showed clearly in what sense the word was used. He holds that precise definitions deaden style and often obscure meaning; sometimes indeed they cloak ignorance. He would preserve for English words the freedom in which they have grown up. He opposes placing them in solitary confinement, in the narrow cell of a scientific strait-jacket; better that Greek or Latin supply the victims. However, the reviewer wants a definition. His question is: What is an upthrust fault? In response one may say: *An upthrust fault is a high-angle fault on which the displacement involved the demonstrable elevation of one side (or both) above its former position with reference to sea level.* The designation "high-angle" implies that the dip of the fault plane exceeds 45°. It is usually between 70° and 90°. *Upthrust* is thus distinguished from *overthrust,* which is the term applied to displacements on planes dipping less than 45°. It will be noted further that the definition does not include the direction of dip of the upthrust fault, whether toward the upthrow or the downthrow. In fact the dip may be toward either or in different parts of the same displacement, here toward one and there toward the other, for such fault surfaces are frequently curved. An upthrust fault may thus be either normal or reverse or may be a hybrid of both types. Considering the forces involved in such displacements it is clear that gravity is one and that an anti-gravity stress must also act. If the latter is the more effective there is upthrusting; if the former prevails there is subsidence, *i.e.,* gravity faulting, aided possibly by a downward directed stress. In large structures both effects may be represented, as for instance in the case of the Dead Sea Trough. There the Judean Peneplain or Matureland is elevated in the high plateaus and also depressed below sea level in the trough. The fault between the two segments is a high-angle fault, approaching 90°. With reference to the plateaus it is an upthrust or ramp; with reference to the trough it is a gravity fault or downthrust. It may be either normal or reverse, according to the direction of dip in any particular section. Upthrusts and upthrust faults are of common occurrence in mountain ranges and plateaus and they are also of many types. Let us keep the generic term free to serve us in the many

[1] SCIENCE, 80: 2085, 562, December 14, 1934.

useful relations in which it can serve adequately so long as it retains its fine old English meanings.

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ALTERATIONS IN THE FOUNDATIONS OF THE EXACT SCIENCES IN MODERN TIMES

IN an article appearing in the October 5 issue of *Die Naturwissenschaften* under the title, "Wandlung der Grundlagen der Exacten Naturwissenschaften in jungster Zeit," Professor W. Heisenberg, theoretical physicist of the University of Leipzig and recent Nobel prize winner, has presented his views on the effects induced in the general scheme of exact sciences by the revolutionary physical discoveries of the past thirty-five years. This presentation is a particularly inviting one, coming as it does from one of the young leaders in theoretical physics, for to such a man, who will undoubtedly be a prominent figure for many years to come, it must be considered an urgent necessity that the importance of the field of science in which he has worked is clearly understood and appreciated. For this reason Heisenberg is careful to point out the various links between the exact sciences themselves and between these and the affairs of everyday life. The manner in which this is done is probably best illustrated by a survey of the text of the article. Such a survey is given in the following paragraphs.

The two major additions to the fields of physics which have been made in the past thirty-five years are those summed up in the expressions, "Relativity Theory" and "Quantum Theory," and were heralded by the discovery of the quantum of action by Planck and the propounding of the special theory of relativity by Einstein. Previous to this, in the period of so-called classical physics, all fields were underlain by a set of basic conceptions which were taken as unquestioned facts and which were the guiding principles of all investigations. In the words of Heisenberg:

> . . . Physics dealt with the behavior of real entities in space and their variation in time. Although merely the character of experiences underlying physics was specified by this, a number of conclusions were drawn concerning the properties of such entities at the same time. One was led to the unexpressed viewpoint that the occurrence of events in time and space is independent of observation, and moreover, that space and time constitute mutually independent classifying categories of events and in this rôle represent an objective reality that is common to all men.

The underlying assumptions of classical physics were contested by the special theory of relativity which found its experimental basis in the well-known work of Michelson and Morley that yielded results contradicting the classical concepts. From the new view-point the classical concepts of an absolute past and future, separated by an instantaneous present that is the same for all observers, were abolished and supplanted by the view that the absolute past and future of two observers is separated by a finite stretch of time which depends upon the relative conditions of observers. These newer views have since received abundant enough experimental verifications that they may now be taken as definite facts of the exact sciences in the same sense as that in which the principles of classical mechanics and thermodynamics are accepted.

In order to emphasize the fundamental importance of this change in attitude Heisenberg states:

> The extraordinary significance of these facts lies, in the first place, in the completely unexpected realization that the natural result of following the route indicated by classical physics compels a change in the foundations of this field. . . . Modern theories do not arise out of revolutionary ideas that are, so to speak, brought in from the outside of exact sciences; they are the results of investigations undertaken with the desire to carry out the program of classical physics. Therefore, at this point one can not compare the beginnings of modern physics with the great revolutions of the past, that is, for example with the work of Copernicus; the ideas of Copernicus were, to a great extent, introduced into the conceptual scheme of contemporary physics from the outside. . . .

The general theory of relativity has revised the concepts of the geometrical properties of space-time and has established a connection between the geometry of the world and the distribution of matter in it. Its experimental justification is not as firmly established as that of special relativity, but it has met no contradiction. The principal conviction of its truth lies in the fact that it presents many stimulating view-points that were previously overlooked. The fact that the fundamental postulate that the geometry of the world depends upon the distribution of matter does lead to a completely self-consistent picturization of gravitational phenomena causes one to anticipate that additional progress will be made on the basis of this theory rather than from a wholly new one, even if experimental contradictions do appear in the future.

The foundations of quantum theory, like those of relativity, arise out of the attempt to extend the classical domain rather than from the introduction of radically new ideas. On the basis of Planck's discovery, the investigations of Lenard and Einstein necessarily led to the adoption of a corpuscular view-point, that is, the classical wave theory was contradicted in performing an experiment suggested by classical reasoning. In exactly the same way, each stage of development of quantum theory up to the present time has been required by contradictions in the previously

accepted scheme. Heisenberg believes in the permanence of many elements of the present theory, in which there exists a curious division between the laws describing the observing apparatus and observed object, the first being discussed naturally in terms of classical views and the second in terms of a complex mathematical formulation, since he regards the second as almost unique. If this is granted, then he believes that the statistical interpretation of quantum theory is almost unavoidable, since it is the only means of bridging the gap between the rigid determinism of classical physics, on the one hand, and the fact that the influence of the measuring apparatus on the observed object is indeterminate because of the nature of the quantum laws, on the other. In answer to the question often asked as to whether or not there exists a set of purely deterministic laws of such a nature that the present-day quantum mechanics takes the same position as Boltzmann mechanics did in the classical theory, Heisenberg answers:

> An exact investigation of this hypothesis indicated at once that these natural laws will be in contradiction with the results of quantum mechanics which are already rigorously established; at no place does quantum mechanics leave room for an extension of its consequences, for the only point at which it contains an indefinite feature is at the division mentioned previously. If one would remove the indefiniteness of quantum theory by extensions at any point defined by natural processes, it would be necessary to remove the division from the place which we have assigned it, and the contradictions between quantum theory and the extension sought for would become apparent.

Just as the voyages of Columbus and Magellan brought to an end a period of belief in which the hypothesis of a flat earth was accepted, so in Heisenberg's opinion the new theories have brought the period of classical physics to an end. That is, the concepts of absolute time and determinacy are to be considered as out of place in the new physics as the concept of "the end of the earth" is to-day. However, the discovery of Columbus did not affect the geography of the Mediterranean Basin in any important respect and in the same way we may believe that certain fields of classical physics, such as mechanics, optics and thermodynamics, will remain unaltered.

The general importance to civilization of modern developments in physics may be classified in two groups on the basis of the following facts: First, the range of pure science that is available for practical use in the applied sciences is now increased by those fields in which modern physics has stimulated research, and second, the philosophical principles which the new physics yields for exploitation are major additions to the whole of human thought.

The development of classical physics brought with it the advances of western civilization that go with the harnessing of power and its use in machines. Since modern physics finds an *experimental* basis in the natural course of classical physics, it is to be expected that as great technological strides will follow from it as did from the development of older fields. That is, it is just the essential continuity of the step from the physics of the last century to that of the present that makes this applicability inevitable. Moreover, since pure science is the spring that feeds all the applied sciences, it is essential for the sake of the continued development of the latter that the former be kept in a state of continuous activity. The neglect of this fact can lead only to technological stagnation and the death of all scientific advance.

The changes which modern physics has brought to philosophical thought are elaborated considerably by Heisenberg, who has a very deep appreciation of this offspring of the recent work. The central topic with which his discussion deals is a general examination of the manner in which modern views curtailed the conclusions that might have been drawn from a complete extrapolation of classical thought. That is, the basis of classical physics was mechanistic in essence and if one exploited these concepts to the limit in a purely abstract way, it was necessary to conclude that the entire universe is to be likened to one machine started at an indefinite period in the past and running toward a fixed destination which can not be altered by means of any internal agency. However, the practical attempt made at carrying these principles to the limit led, as we have seen, to the modern developments, from the standpoint of which the extrapolation is meaningless.

In a similar way, one might have attempted to approach an understanding of ultimate reality through classical lines, and again succeeding developments would compel one to abandon any conclusions that might have been drawn. The general view to be gained from facts of this kind is that any field of thought may be expected to yield the answer to only a limited field of questions. An attempt made at extension in a purely abstract manner will lead to results that can not be true. In this connection Heisenberg states:

> Thus Nature influences modern natural science more than the earlier form in such a way as to place the old question of the realization of reality upon a new basis and to answer it in a new manner. Previously the pattern of exact science led to a philosophical system in which a definite truth—perhaps the "Cogito, ergo sum," of Descartes—was the starting point from which all problems of world-view were to be attacked. Nature in modern physics has reminded us clearly, however, that we

may not hope to reach the entire region of the understandable from such a fixed basis of operation. Instead, we shall always come to essentially new knowledge in the manner of Columbus who had the courage to leave everything but the knowledge of known land behind with the determined and devout hope of finding land again on the other side.

Just to what extent this view may be continued is of course an unanswerable question, but at any rate it indicates the path which the science of the near future must follow and may lead to a further unification of those concepts of existence with which science can deal.

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FURTHER COMMENTS ON THE TRIHYDROL CONTROVERSY

IN a recent review[1] of the properties of water and their possible biological significance by Dr. Jahn and myself, we made the following remark (p. 326): "It is hoped that our work on the biological effect of ice- and steam water will stimulate more extensive research on the properties of water even if this proves fatal to our present working hypothesis that trihydrol aggregates play an essential rôle in certain types of living cells." At the time of the first experiments indicating the stimulating action of ice water the only published physical test of the rate of attainment of polymer equilibrium indicated a considerable hysteresis effect during the exhaustion of the ice-forming power of water. Since that time several chemists and physicists, although skeptical of the stimulating action of ice water, have afforded ample evidence of the psychological stimulation of our work on water research. Menzies, LaMer and Miller, Ellis and Sorge and more recently Dole and Wiener, although not repeating our procedure, have published what they consider to be negative evidence.

Dole and Wiener[2] tested my trihydrol hypothesis by determining the density of recently condensed water which had been partially frozen. Under these conditions no difference in density was found. Only four fifths of the water was frozen, and moreover these rapidly frozen small samples of water do not yield large crystals from which the best biological results are obtained. Dole points out that trihydrol is supposed to have a lower density than dihydrol, but he completely overlooks the fact that the lower polymer monohydrol, which may be enriched in recently condensed steam water, has like trihydrol a low density. Density determinations then would be of very ambiguous significance for the comparison of two water samples, each supposedly having a slightly enriched polymer of low density. That monohydrol has a bulky structure is seen in the solution volume curves of Bousfield and Lowry, in which a contraction appears at higher temperatures resembling the contraction at lower temperatures due to the breakdown of the trihydrol molecules of large specific volume. Moreover a slight change in the configuration of the quartz-like structure of water of Bernal and Fowler would not show great density differences. It is also possible that the H–O–H angle or the activity of auxiliary fields undergoes a temporary change.

Dole and Wiener also determined the density of water from recently melted clear block ice in which crystal growth had occurred. This water had an excess density of 2.4 parts per million compared to recently condensed water. In this connection the authors fail to consider the hypothesis of Uhlmann that the sublimation of aged ice may concentrate the heavy hydrogen isotope, which may possibly account for the enhanced biological effect of water from old samples of natural ice. Moreover, Gilfillan[3] finds that fractional crystalization of water concentrates the heavy hydrogen isotope to a slight extent (which, however, is complicated by the fact that O^{16} is concentrated in respect to O^{18}).

It should also be pointed out that Dole and Wiener worked at a higher temperature (23°) than that at which our biological experiments are usually carried out (10°). There is evidence that the attainment of polymer equilibrium is more rapid at higher temperatures. Also in some of our tests a continuous stream of ice water was used or the cells were temporarily exposed to the ice water at a lower temperature than that of the recently condensed water.

There are, of course, several positive tests for the differences between ice water and steam water. On the physical side it has been found that the onset of freezing, the exhaustion of the ice-forming power of water and the diamagnetic susceptibility indicate a polymer lag. On the biological side the most recent evidence is that of Hegarty and Rahn, who find that recently condensed water retards bacterial growth which can not be an impurity effect, for this property disappears after a few hours. Moreover, the water samples were bubbled with air to prevent a gas effect. Even Professor Menzies, an ever-vigilant critic of my ice-water work, admits the possibility that the biological method may be more sensitive than some of the physical tests.

It appears that all these difficulties are in large part due to the unsatisfactory state of our knowledge of matter in the liquid state. Maass and Steacie[4]

[1] T. C. Barnes and T. L. Jahn, *Quart. Rev. Biol.*, 9: 292, 1934. This review contains references to papers mentioned in this note.

[2] M. Dole and B. Z. Wiener, SCIENCE, 81: 45, 1935.

[3] E. S. Gilfillan, *Jour. Am. Chem. Soc.*, 56: 2201, 1934.

[4] O. Maass and E. W. R. Steacie, "An Introduction to Physical Chemistry," New York, 1931.

contrast the relative simplicity of the solid and gaseous state with the "great complications" which arise in the physical properties of associated liquids. From the biologist's point of view it is unfortunate that vital phenomena appear to be manifested by liquids and not by gases or crystals.

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SCIENTIFIC BOOKS

A NEW DICTIONARY

Webster's New International Dictionary. Second Edition. pp. i–xcvi, 1–3210. G. and C. Merriam Company, 1934. $20.00.

ONE scarcely thinks of an unabridged dictionary as a botanical reference book, yet it is the one work generally accessible to all readers to which they may turn for the spelling, meaning, pronunciation and derivation of hundreds of botanical terms or for brief information about thousands of different plants. In the definition of non-botanical words, botanical users of the dictionary can certainly rely with confidence on its accuracy and inclusiveness. They will naturally have a greater interest in its treatment of the huge botanical vocabulary of plant names and technical terms.

The English language is remarkable for its world-wide use and for the readiness with which it assimilates foreign nouns. Plants of economic value always have local names, and an extraordinary number of such names have found English use. Opening the book at random, I find these plants included and defined by reference to the species or to the genus when the name so applies: lace bark (4 kinds), lace fern (2 kinds), lace flower (3 kinds), lace grass, lace leaf, lace plant (2 kinds), lace tree, lace vine, lace wood, Lachenalia, Lachnanthes. It is obviously not within the province of a dictionary to give a diagnosis of every plant, nevertheless, a surprising amount of information is presented. *Titi,* for example, is defined as a tree (*Cliftonia monophylla*) of the southern United States, having glossy leaves and racemes of fragrant white flowers succeeded by one-seeded drupes; the name is also used for the related genus *Cyrilla;* in South Carolina for the sorrel tree, and in Australia for *Cordyline terminalis.* Turning now to these genera, we find that the last is a small genus of Old World plants of the Liliaceae, with *Taetsia* as a synonym; *Cyrilla* is the typical genus of the Cyrillaceae, and *Cliftonia* a monotypic genus of the same family. The Cyrillaceae are referred to the order Sapindales, which is also briefly defined. Even the synonym *Taetsia* is entered. Of course the dictionary is not an *index generum,* and one easily notes numerous omitted generic names of unimportant plants, such as *Sclerolepis.* Apparently all family names are entered and referred to their order. Opinions are even expressed concerning the validity of some names; the Leguminosae, for example, are defined as a group and stated to contain three separate families. The Guttiferae, strange to say, are mentioned among the rare or obsolete words at the bottom of the page, notwithstanding their recognition by Engler and Prantl, although the segregates Hypericaceae and Clusiaceae are listed. In nomenclature, the rules of the revised International Code of 1930 have been followed as far as possible, but care has been used to avoid the publication of new names. Altogether, the list of vernacular names is remarkable for its length and completeness and surpasses any preceding list in any language, while the list of genera is second only to Willis' Handbook in its general utility.

Botanical terms must have offered a serious problem to the editor. Every botanist feels it his right to coin new terms of Greek or Latin derivation, and many of them are never used except by their author. Every one of these must be discovered in literature, a task of no mean proportions; on every one a decision must be made as to the appropriateness of listing it; for every one a definition must be formulated. Since earlier definitions do not exist, the original use of the word must be studied and its meaning derived *de novo.* Among the recent terms not included in the edition of 1928, but defined in the new edition, I note the following: amphisporangiate, association, consociation, consocies, crossover, cultigen, ecesis, euploid, heteroploid, hydrarch, layer, sciophyte, sere, succession, trisomic and xerarch, and the list could easily be extended greatly. As a botanical glossary, the dictionary is obviously the most complete work extant.

A special table of ferns occupies two columns and gives the common name, scientific name, geographical distribution and use of all species which have an English name. A similar table of grasses occupies no less than two columns. There are full-page plates, mostly in color, illustrating orchids, poisonous plants, state flowers, trees and wild flowers, while hundreds of text figures aid in the clear definition of an equal number of terms.

Mr. Norman Taylor was the general editor for botany and was assisted by a staff of specialists. One of these was my colleague, the late Arthur Hollick, and I had several opportunities to observe the meticulous care with which paleobotanical definitions were prepared. The editor, his assistants and the publish-

ers are all to be congratulated on a distinct botanical achievement.

H. A. GLEASON

NEW YORK BOTANICAL GARDEN

THE MEMOIRS OF A BOTANIST

Erinnerungen und Welteindrücke eines Naturforschers. By HANS MOLISCH. Pp. 232. Emil Haim, Wien and Leipzig. 1934, Rm. 9.00.

WHAT makes the reading of botanical history so interesting are accounts of the personalities who participated in the advancement of this branch of science. Here belong the memoirs of outstanding botanists, especially of men whose leadership has contributed as much to botanical progress as their own research work. One of these men is Hans Molisch. His latest book is fascinating because of the many problems which occupied him during his life, the many botanists whom he met and the broad cultural background of his life and travels.

Molisch was born in 1856 at Brünn in the former Austro-Hungarian empire and as a nine-year-old boy he met Gregor Mendel, who was a neighbor and friend of the family. From his father, who was a horticulturist and commercial florist, Hans Molisch acquired in his youth a practical knowledge of gardening which in turn aroused his interest in theoretical botany and especially in plant physiology. This early training showed itself in a later book on "Plant Physiology as a Theoretical Basis for Horticulture" (1915). There, Molisch said, th plant physiologist should learn from the practical horticulturist and the latter in turn from the physiologist. It became his most popular book and has had six editions to date, besides being translated into several languages.

Molisch attended the University of Vienna, where he became Wiesner's assistant. Later he taught at the Technische Hochschule in Graz, where the author of this review was one of his students. From Graz he was called to the German university of Prague and finally, as Wiesner's successor, to Vienna.

A considerable portion of the book is devoted to observations of tropical plant life during a visit to Buitenzorg in Java in 1897–98. On his return trip Molisch visited the United States. From 1922 to 1925 he taught plant physiology in the University of Sendai in Japan where he had been called to organize the botanical division of the newly founded institute of biology. After his retirement from the University of Vienna, Molisch taught for one year (1928–29) at the institute for plant physiology of Sir Jagadi Chandra Bose in Calcutta and traveling home he again visited the United States. He always showed great interest in the botanical work done in this country and had accepted an exchange professorship at Columbia University when the great war broke out, which frustrated this plan.

The "Erinnerungen" gives a detailed account of the research work done by Molisch. Among his earlier studies he mentions a histologic chemistry of vegetable foods (1891), a treatise on iron in its relation to plants (1892), investigations about the nutrition of algae, the freezing of plants and the luminosity in plants. Fruits of his first visit to the tropics were researches about the forming of indigo, of palm-wine and about the secretion of water by liana-stems. He was always greatly interested in plant chemistry and in 1913 he published a "Microchemistry of Plants," of which three editions have appeared to date. His book on plant physiology and horticulture (1915) has been mentioned. The three years in Japan resulted in a volume entitled "Plant Physiology in Japan on the Basis of Personal Observations" (1926) and the more personal experiences of this trip found their expression in a book "In the Land of the Rising Sun" (1927). The observations gathered during his second trip to India are contained in a book entitled "A Naturalist in India" (1930). Even after retirement from teaching such contributions were made by Molisch, as "Duration of Plant Life" (1929) and "Plant Chemistry and Plant Relations" (1933). Naturally all Molisch's books are written in German and the titles as given in this review are translated into English.

Any student of botany who can read German fairly fluently will find the "Erinnerungen und Welteindrücke eines Naturforschers" easy and pleasant reading and will enjoy making the acquaintance, through this book, of an excellent botanist and a most delightful personality.

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REPORTS

APPROPRIATIONS FOR GRANTS-IN-AID BY THE NATIONAL RESEARCH COUNCIL

As announced in SCIENCE for January 18, 1935, the National Research Council has been given funds for grants-in-aid for the year 1935. Applications for grants from this fund must be in the hands of the secretary of the Committee on Grants-in-Aid on or before April 1, 1935. Additional information and blank forms for filing application will be furnished upon request. Action on these applications will be taken about the middle of May.

At meetings in November and December, 1934, the

Committee on Grants-in-Aid made the forty-four following awards:

PHYSICAL SCIENCES

J. W. Beams, professor of physics, University of Virginia, "investigation of Allison's magneto-optic method of chemical analysis"; P. Gerald Kruger, assistant professor of physics, University of Illinois, "artificial radioactivity"; M. Stanley Livingston, instructor in physics, Cornell University, "high speed ions"; Overton Luhr, assistant professor of physics, Union College, "source of helium ions"; Walter C. Michels, associate professor of physics, Bryn Mawr College, "temperature variations of the photoelectric effect"; Rose C. L. Mooney, assistant professor of physics, Newcomb College, Tulane University, "x-ray crystal structure"; J. C. Stearns, professor of physics, University of Denver, "cosmic rays"; Joel Stebbins, director of the Washburn Observatory, University of Wisconsin, "photometry of stars."

ENGINEERING

Walter G. Whitman, professor of chemical engineering, Massachusetts Institute of Technology, "gel structures in the setting of cement."

CHEMISTRY

J. R. Bates, L. S. Anderson and J. C. Halford, assistant professors of chemistry, University of Michigan, "Raman spectra of compounds of deuterium"; Ralph A. Beebe, associate professor of chemistry, Amherst College, "measurement of the heats of adsorption of gases on solid adsorbents at low temperatures"; Malcolm Dole, instructor in chemistry, Northwestern University, "studies on the glass electrode"; W. George Parks, assistant professor of chemistry, Rhode Island State College, "the e.m.f. method for determining heats of dilution and transfer."

GEOLOGY AND GEOGRAPHY

Kenneth E. Caster, instructor in geology, Cornell University, "the stratigraphy and paleontology of the Pocono formation of Pennsylvania and adjoining territory"; Maurice Ewing, instructor in physics, and Albert P. Crary, assistant in physics, Lehigh University, "a geophysical investigation"; Frank F. Grout, professor of geology, University of Minnesota, "the mechanics of igneous action"; Elmer H. Johnson, industrial geographer, Bureau of Business Research, University of Texas, "physical and economic characteristics of the natural regions of the Gulf Southwest"; George W. Rust, postgraduate student in geology, University of Chicago, "studies of a newly discovered center of ancient volcanic activity in southeastern Missouri"; J. Russell Whitaker, assistant professor of geography, University of Wisconsin, "regional geography of southern Ontario."

MEDICAL SCIENCES

G. Howard Bailey, associate professor of immunology, School of Hygiene and Public Health, Johns Hopkins University, "the heterophile antigens of bacteria"; David M. Greenberg, associate professor of biochemistry, University of California, "the effect of diets low in magnesium on Vitamin G requirement"; Louis N. Katz, director of cardiovascular research, Michael Reese Hospital, assistant professor of physiology, University of Chicago, "various factors operating to modify the coronary blood flow"; Pearl Kendrick, associate director, Bureau of Laboratories, Michigan Department of Health, "the antigenic properties of bacillus pertussis"; Albert P. Krueger, associate professor of bacteriology, University of California, "the nature of bacteriophage"; Orthello R. Langworthy, associate professor of neurology, Johns Hopkins University Medical School, "control of the urinary bladder by the peripheral and central nervous system"; J. P. Quigley, assistant professor of physiology, School of Medicine, Western Reserve University, "the rate of absorption of oxygen from the intestinal lumen of unanesthetized dogs"; H. D. Senior, professor of anatomy, University and Bellevue Hospital Medical College, "the anomalies of the limb arteries in embryos."

BIOLOGICAL SCIENCES

Ernest Anderson, professor of chemistry, University of Arizona, "the polyuronides of woods"; Robert K. Enders, assistant professor of zoology, Swarthmore College, "the myology and general anatomy of Didelphids, Alouatta, Cebus and Bats"; Denis L. Fox, instructor in the physiology of marine organisms, Scripps Institution of Oceanography, "physiological effects of deuterium oxide on certain marine animals"; F. G. Hall, professor of zoology, Duke University, "the physiological effects of high altitudes on man and animals"; Hudson Hoagland, professor of general physiology, and director of the Biological Laboratories, Clark University, "repetitive rhythms of activity"; Carl L. Hubbs, associate professor of zoology, University of Michigan, "interspecific hybridization in fishes"; F. B. Isely, professor of biology, Trinity University, Texas, "acridian plant and soil relations"; Frank R. Lillie, dean, division of biology, University of Chicago, "the mathematical analysis of feather pattern as affected by sex hormones and thyroxin"; H. D. Reed, professor of zoology, and Myron Gordon, Heckscher research zoologist, Cornell University, "cytological investigations of certain species of fish"; C. B. vanNiel, associate professor of microbiology, Hopkins Marine Station, "study of the pigments of purple bacteria"; John E. Weaver, professor of plant ecology, University of Nebraska, "effects of great drought upon prairie vegetation and the relation of natural plant cover to soil erosion."

ANTHROPOLOGY AND PSYCHOLOGY

Forrest E. Clements, associate professor of anthropology, University of Oklahoma, "mound sites of the Lower Mississippi prehistoric culture in eastern Oklahoma"; T. M. N. Lewis, professor of archeology, University of Tennessee, "archeological sites in Tennessee"; Morris E. Opler, research assistant in anthro-

pology, University of Chicago, "cultural relationships of Apache tribes"; George M. Peterson, assistant professor of psychology, University of New Mexico, "the effect of variations in the wave form of an electric stimulus on the response of conscious animals"; Otis C. Trimble, associate professor of psychology, Purdue University, "analysis of wave-form as a determining factor in auditory localization"; Wilson D. Wallis, professor of anthropology, University of Minnesota, "anatomic lag."

ISAIAH BOWMAN,
Chairman, National Research Council

SCIENTIFIC APPARATUS AND LABORATORY METHODS

REGULATING THE FLOW OF SOLUTION FOR PLANT CULTURES

SEVERAL articles have recently appeared in SCIENCE on devices for securing a slow and accurately controlled flow of a liquid.[1] The purpose of the present note is to call attention to the simple and efficient method devised by Shive and Stahl[2] and to describe a modification of this method that permits considerable latitude in regulating the rate of flow.

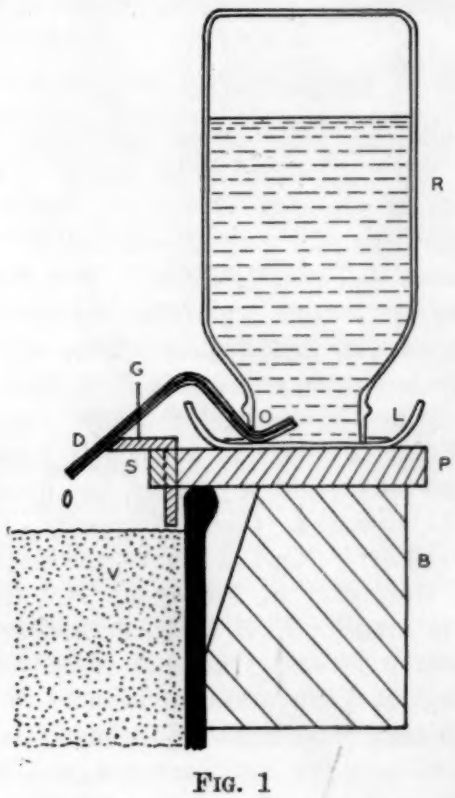

FIG. 1

Fig. 1 shows the main features of the Shive and Stahl apparatus. The solution reservoir (R) is a 2-quart Mason jar with a V-shaped orifice (O) that has been cut with a whetstone. The reservoir, acting as a Mariotte flask, maintains an approximately constant level of solution in the glass dish (L)—a Woolworth "ash tray." Solution flows at a practically constant rate through the small-bore delivery tube (D) and drips regularly into the sand in the culture vessel (V). The apparatus is supported on a platform (P) provided with a bracket (B).

[1] J. H. Wales, SCIENCE, 79: 545–546, 1934; W. A. McCubbin, SCIENCE, 80: 144, 1934; H. F. Pierce, SCIENCE, 80: 339, 1934; R. H. Lambert, SCIENCE, 80: 361–362, 1934.

[2] J. W. Shive and A. L. Stahl, *Bot. Gaz.*, 84: 317–323, 1927.

The modification consists in the addition of a notched support (S) for the delivery tube. The desired rate of flow through the delivery tube (D) is then readily obtained by adjusting the position of the apparatus on the platform (P). Movement to the right raises the delivery tube (D), since this rests on the notched support (S) and is guided between two wire nails (G); this decreases the "head" and, consequently, decreases the rate of flow through the tube. To increase the rate of flow, the apparatus is moved to the left on the platform. A change in "head" of about 3.5 cm may be obtained with the apparatus illustrated. After the apparatus has been adjusted to the desired rate of flow, a mark is made with a wax pencil on the delivery tube even with the guide nails (G); this allows immediate resetting of the apparatus after the reservoir is refilled.

The addition of the tube support allows the rate of flow to be varied through a considerable range, and therefore obviates the necessity of extreme care in the selection of capillary tubing of suitable bore. In culture studies the rate of flow may easily be increased as the plants grow.

Small fluctuations in the solution level in the reservoir dish (L) occur, since air is admitted intermittently into the reservoir; changes in the temperature of the air in the reservoir also affect the solution level. These sources of variation in the rate of flow, though generally not significant in culture studies, may be avoided by employing a separate constant-level device, provided with an overflow.[3] But the simplicity, compactness and ease of manipulation of the apparatus of Shive and Stahl make it extremely useful in investigations of the mineral nutrition of plants.

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THE CHICAGO SOIL–NUTRIENT–TEMPERATURE TANK

THE Botanical Laboratory of the University of Chicago has developed the Wisconsin soil-temperature tank into a soil-nutrient-temperature tank.[1] By its use the direct pathogenic effects of deficient soil aera-

[3] S. F. Trelease and B. E. Livingston, SCIENCE, 55: 483–486, 1922. Pierce, *loc. cit.*

[1] W. H. Tisdale, *Phytopathology*, 7: 356–360, 1917; L. R. Jones, *Plant World*, 20: 229–237, 1917; J. John-

tion, metal ions and sharply restricted root development, as well as their indirect pathogenic effects in disposing plants to other deleterious influences, are avoided. It permits growth of control plants that compare favorably in vigor, form, vegetative growth, flowering and fruiting with plants grown in the open in good soil.

The tank itself, a wooden box with a removable galvanized iron container that maintains a constant water level, is the same as that used in the Wisconsin model. A "Sylphon" metal diaphragm thermo-regulator, not shown in the diagram, is used instead of the glass-mercury regulator of the latest Wisconsin tank. Installation of relays, not shown in the diagram, and of insulated heating units is essentially that of the Wisconsin tank.

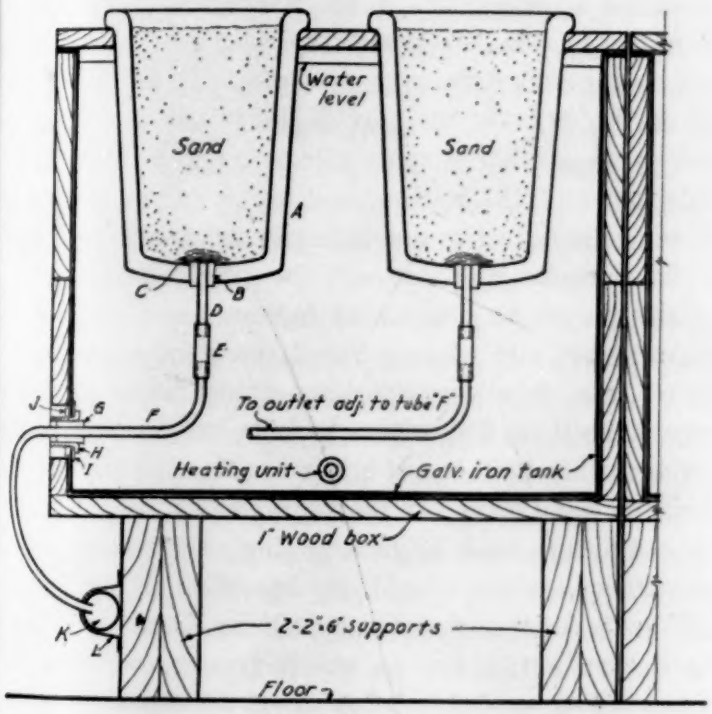

FIG. 1. Section of the Chicago soil-nutrient-temperature tank.

The critical change consists in substitution of six 8-liter glazed earthenware percolator urns for the 8 small, undrained metal containers used in the Wisconsin tank. These urns have been used by Nightingale, Robbins[2] and others of the New Jersey Experiment Station, and by Kraus, Harrison,[3] Mitchell, Shull, Eaton and others of the Chicago laboratory, for constant drip and intermittent application of mineral nutrients to plants grown in nitrogen-free quartz sand. The urns are manufactured by the American Metalware Company of Chicago for use as coffee percolators. The wide-flanged rim of the urn (A) permits its suspension from the lid of the temperature tank into the water bath, and the opening in its bottom permits connection with a drain through the side of the tank.

The drain-hole of the percolator urn is fitted with a one-hole rubber stopper (B) bearing a 3/8-inch glass tube (D) about 3½ inches long. The upper end of the glass tube is fitted flush with the bottom of the urn. Since the tanks are set up in batteries of six, two wide and three long, placed end to end, the outer side wall of each tank is perforated by six one-inch holes, one hole for each of the urns. The holes are drilled through the inner galvanized iron lining and the outer wood case, 2 to 3 inches above the floor of the tank. A ¾-inch Chase galvanized iron lock-nut bushing and an iron washer ⅛-inch thick are soldered into each hole of the metal tank. The washer (I) is placed on the inside and the lock nut (J) on the outside of the metal tank, the washer setting the bushing (H) in far enough so that the metal container is readily placed into or removed from the wooden tank. The bushing is fitted from the inside of the tank with a No. 3 rubber stopper (G) perforated with a 3/8-inch hole. A copper tube (F) 3/8-inch bore is fitted through the hole of the stopper, and the part projecting outside the tank is bent downward sufficiently to carry its end under the edge of the bottom of the tank, where it is inserted into a 1⅝-inch galvanized iron drain-pipe (K). The drain-pipes, one on each side of the battery of tanks, are fastened (L) to the wooden base which raises the tanks about 6 inches above the floor at the point of least elevation. The base is set in about 4 inches from the outer edge of the battery of tanks. The copper tubes are 18 or 24 inches long, depending upon which row of urns they drain. The inner free end of each copper tube is connected by means of a short piece of rubber tubing (E) to the lower, free end of the glass tube projecting through the stopper of the drain-hole of the percolator. The opening in the bottom of the percolator is covered with a mass of glass wool (C) or with an inverted porous flower pot whose drain-hole is covered with glass wool. Good drainage and aeration of the urn are thereby assured, and the likelihood of clogging of the copper drain tube reduced to a minimum. The glazed urn may be filled with soil, or preferably, for controlled nutrition studies, with pure white quartz sand.

The Wisconsin tank has proved an extremely useful instrument for studies in ecologic phytopathology,

son and R. E. Hartman, *Jour. Agr. Res.*, 17: 41–101, 1919; J. G. Dickson, *Jour. Agr. Res.*, 23: 837–870, 1923. In reply to an inquiry relative to the history of soil-temperature tanks, Professor Charles F. Hottes, of the University of Illinois, states that he too had developed a soil-temperature tank that was first installed "late in 1914 or early in 1915." Neither the Hottes tank nor its use has been described in publications.

[2] W. R. Robbins, *New Jersey Exp. Sta. Ann. Rpt.*, pp. 178–179, 1927.

[3] C. M. Harrison, *Plant Physiology*, 9: 83–106, 1934.

especially of diseases whose causal complex includes an infective agent. It has enabled experimental demonstration that soil temperature, moisture and reaction, singly, or in conjunction with each other and/or with other ecic factors, especially air temperature and moisture, are part of the etic complexes of infective plant diseases.[4] Culture of plants in pure quartz sand in self-draining containers has proved an extremely useful tool in physiologic and horticultural studies of the New Jersey and Chicago groups and of many others, and incidentally has contributed to analysis of the causal complexes of non-infective pathic events in plants. It permits sudden changes in nutrient treatment, such as a complete and rapid flushing with distilled water of all nutrients from the soil, with consequent rapid changes in growth status of the plant. It also permits collection of the drip for its continuous or periodic chemical analysis, for determination of the pH of the soil solution, and for reapplication, if desired. The Chicago tank combines the advantages of the Wisconsin tank with those of nutritional studies by continuous drip or discontinuous methods of applying nutrients and other ingredients to the plant substrate. Coupled with use of shades and lamps, the tank also is suited for analysis of the rôle, direct and indirect, of carbohydrate nutrition as a hygio- and pathogenic factor in development, maintenance and reproduction in plants.

The tank has been put to the following uses in the Chicago laboratory: a study of the relation of ecic factors to the processes, structures and behavior of fruit trees by Dr. G. T. Nightingale, of the New Jersey Experiment Station,[5] who put the tank to its first extensive use; production and cure of iron excess and deficiency in apple trees by Nightingale and the writer, independently; studies by the writer with the assistance of W. S. Cook and W. S. Phillips, of the relation of the carbohydrate-nitrogen nutrition of the apple tree to its positive and negative disposition to pathogenic infection by *Erwinia amylovora;* studies by Miss E. Goldberg of the relation of carbohydrate-nitrogen nutrition of susceptible and insusceptible varieties of cabbage, under controlled air and soil temperatures, to their disposition to pathogenic infection by *Fusarium conglutinans,* soil-borne fungous constituent of the etic complex of cabbage yellows; a study by W. S. Cook of the relation of nutrition of susceptible and insusceptible varieties of tomato to their disposition to pathogenic infection, under controlled air and soil temperatures, by *Fusarium lycopersici,* a soil-borne pathogenic fungus; and a study by Miss V. Eggers of the relation of nutrition of flax, under controlled soil and air temperatures, to wound healing and regeneration of an axis following experimental decapitation. In addition, to determine further the adaptability of the tank, experiments are being started to study the relation of nutrition to: (1) healing in apple and pear following non-infective and infective wounding; and (2) pathogenic infection for: (a) wheat and *Puccinia graminis tritici;* (b) cabbage and *Plasmodiophora brassicae;* (c) tomato and *Phytomonas tumefaciens;* (d) tomato and attenuated aucuba and yellow aucuba viruses; and (e) tobacco and *Thielavia basicola.* Of these experiments, 2e is being carried out by Miss F. L. Jewett, the rest by the writer and Mrs. H. W. Wilcox.

Results of the experiments indicate that the Chicago tank is well suited for studies, under controlled air and soil temperatures and controlled light and soil nutrient applications, of the relation of plant nutrition to (1) non-infective pathic events of plants, such as excess and deficiency diseases; (2) infective diseases whose etic complex includes an air-, insect-, water- or soil-borne virus, schizomycete or filamentous fungus; and (3) healing and organ regeneration following non-infective and infective wounding of plants.

The results also support the proposition that no plant should be designated immune, resistant or insusceptible, and more particularly, genotypically immune, etc., to a particular non-living factor or living agent, until its disposition to influence by that factor or agent has been tested under a wide range of factors ecically significant for the plant under consideration. The Chicago tank is suitable for such testing. The results of its use should call attention to the proposition that disposition (susceptibility, insusceptibility) is not an entity but an abstraction symbolizing the observed or probable behavior of an organism or its parts evaluated with reference to their relative capacity for reacting adaptively, non-adaptively or apparently not at all, to a given internal or external factor. Disposition is always a phenotypic expression, a resultant of an interplay of factors internal and external to the biologic system under analysis. Acceptance of this proposition is one conceptual means of bridging the chasm that exists in the thinking of many between genetics and developmental physiology. The so-called "genotypic" disposition is not a preformed material or immaterial something passed from parent or parents to progeny, but an analytic isolate from the causal complex of that phase of behavior designated as disposition. It symbolizes, in part, the relatively invariant ingredients and their organization that an individual receives from parent or parents. Possibly results obtained through use of the Chicago tank and similar tools may help to repair some of the mischief done in biologic speculation and experimen-

[4] L. R. Jones, *Trans. Wis. Acad. of Sciences, Arts and Letters,* 20: 433–459, 1922.

[5] G. T. Nightingale, *Bot. Gaz.,* 1935.

tation through unconscious hypostatization of disposition, including aggressivity, pathogenicity and virulence, and of similar concepts common to physiology, pathology and genetics.

Details of the experiments will be published elsewhere.

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SPECIAL ARTICLES

THE ROLE OF THE CARBAMINO COMPOUNDS IN THE TRANSPORT OF CO_2 BY THE BLOOD[1]

SINCE Siegfried[2] first prepared salts of carbamic acid by the reaction of CO_2 and amino-acids, and demonstrated analogous compounds of CO_2 and proteins in quite alkaline solutions, the rôle of these carbamino compounds of protein, particularly hemoglobin, as carriers of CO_2 in the blood under physiological conditions has received support by Henriques,[3] Margaria and Green[4] and others. In a recent paper, particularly, Meldrum and Roughton[5] report experiments on the reaction between CO_2 and amino-acids as well as hemoglobin. In brief, they observed that CO_2 was taken up by amino-acids or hemoglobin (to which cyanide had been added to inhibit the rapid enzyme catalysis of the hydration of CO_2 to carbonic acid) in two phases: (1) a very rapid one which they assert, correctly we believe, to be due to the formation of CO_2 in the carbamino form and (2) a slow uptake which is due to the formation of carbonic acid. From their values of carbamino-CO_2 in hemoglobin solution calculated from the *rapid* uptake, they constructed "non-bicarbonate" or carbamino-CO_2 absorption curves for hemoglobin which they "assumed to be practically the same for normal blood and for cyanide blood." They came to the conclusion, which at first sight seems strongly supported by their observations, that carbamino-hemoglobin plays a very important rôle as a CO_2-carrier in the blood. We believe, however, that the above assumption is erroneous because the equilibrium system which they studied was entirely different from the equilibrium system (*i.e.*, normal blood without cyanide) to which they applied their experimental data. Therefore, we believe that their conclusions about the physiological rôle of carbamino-CO_2 derives no support from these experiments.

This paradoxical situation arises as follows. An aqueous solution of an amino-acid, *e.g.*, glycine, to which has been added one or less equivalents of base, and which hence contains a concentration of amphanion, COO^-CNH_2, equal to the concentration of base, when suddenly allowed by equilibration to react with a CO_2 gas phase, forms carbamate, *viz.*:

(1) $COO^-CNH_2 + CO_2 = COO^-CNHCOO^- + H^+$

In addition, CO_2 reacts to form carbonic acid, *viz.*:

(2) $CO_2 + H_2O = H_2CO_3 = H^+ + HCO_3^-$

Both reactions decrease pH, since both carbonic and carbamic acid are about a thousandfold stronger than glycine. In consequence the amount of COO^-CNH_2 diminishes in favor of $COO^-CHN_3^+$ and a greater pressure of CO_2 is needed to obtain a given concentration of $COO^-CNHCOO^-$.

Now reaction 1 is very rapid even at 0° C., whereas reaction 2 is very slow. It follows then that if the equilibration is allowed to go on for a short time only (*i.e.*, about one minute at 0° C.) the carbamate reaction will be practically complete, while the carbonic acid reaction will be scarcely begun. In effect, there is an equilibrium established which is one involving CO_2, carbamate and amino-acid *but in which no carbonic acid whatever is present* (Case 1). This equilibrium affords a convenient and illuminating laboratory dissection of the reaction but has no counterpart in nature.

On the other hand, if the equilibration is allowed to go on sufficiently long, reaction 2 will be completed and the equilibrium will also include carbonic acid (as well as its ions HCO_3^- and $CO_3^=$) and will be entirely different (Case 2). This *complete* reaction is the one which occurs in the blood and therefore the only one of physiological significance.

Now Meldrum and Roughton's experiments, both on amino-acids and hemoglobin, were especially designed to bring about the first equilibrium only, but the experimental facts so elicited were applied without modification to the second equilibrium state and conclusions drawn therefrom apparently without realization that the two systems were different.

The complete dissimilarity between these two cases can be shown by our own experiments (Case 1). In Fig. 1 is shown the equilibrium curve of carbamino concentration as a function of P_{CO_2} and pH in a 0.1 M glycine solution with 0.05 M of base. The curve calculated on the supposition that *no* carbonic acid or its ions are formed agrees with our (unpublished) experiments on amino-acids and hemoglobin and Meldrum and Roughton's work on hemoglobin, under circumstances eliminating the formation of H_2CO_3. From this curve it is possible to calculate the mass

[1] From the John Herr Musser Department of Research Medicine, University of Pennsylvania, Philadelphia.

[2] M. Siegfried, *Zeits. Physiol. Chim.*, 44: 85, 1905.

[3] O. Henriques, *Biochem. Zeits.*, 200: 1 *et seq.*, 1928.

[4] R. Margaria and A. A. Green, *Jour. Biol. Chem.*, 102: 611, 1933.

[5] N. U. Meldrum and F. J. W. Roughton, *Jour. Physiol.*, 80: 143, 1933.

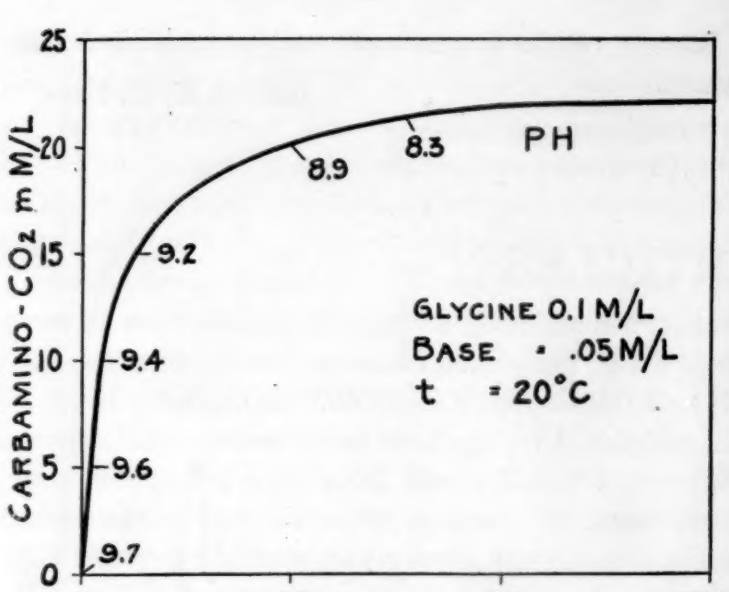

FIG. 1. Case 1. Equilibrium curve of 0.1 M glycine (with 0.05 M of base) and CO_2 showing the concentration of carbamino-CO_2 as a function of the partial pressure of CO_2. Equilibrium is assumed to exclude the formation of H_2CO_3 or its ions. t = 20° C.

action constant of the amino-acid-carbamino-CO_2 equilibrium.

Case 2: In Fig. 2 the curve of carbamino concentration for the same solution has been calculated from

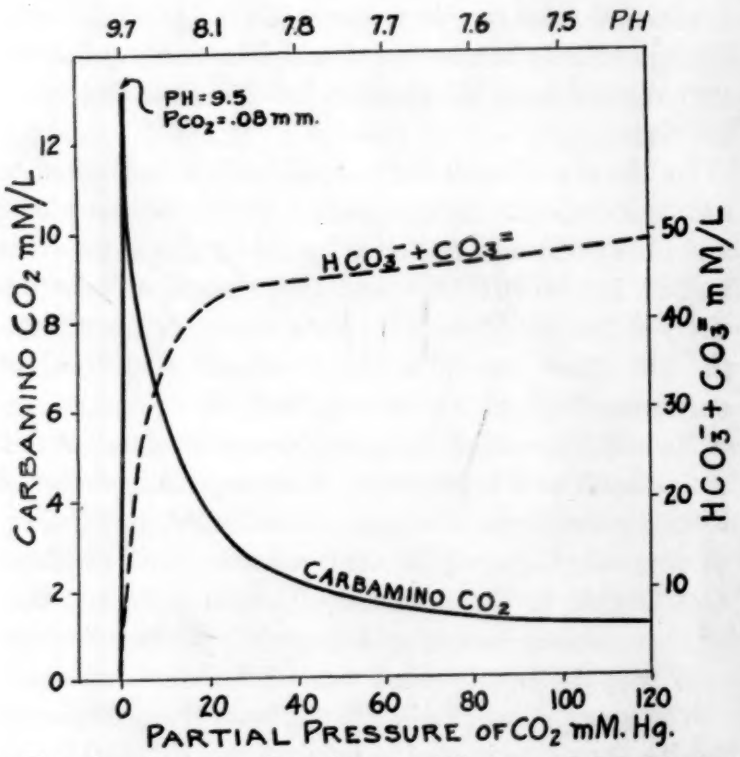

FIG. 2. Case 2. Complete equilibrium of 0.1 M glycine (0.05 M of base) and CO_2 showing (carbamino-CO_2) concentration as a function of Pco_2 calculated from the amino-acid carbamino-CO_2 mass action constant. H_2CO_3 and its ions are included.

this constant at 20° C., *but in this case the equilibrium includes H_2CO_3 and its ions.* The two cases, both in complete agreement with our experiments, are easily seen to be totally unlike. Fig. 1 shows that the total carbamino concentration approaches half of the base concentration as a limit at high Pco_2 and that at intermediate values of Pco_2 the carbamino concentration is high and *increases* appreciably per mm (Hg) change of Pco_2. Whence by analogy one would conclude that carbamino hemoglobin, if it behaved in a similar way, would be an important carrier of CO_2 in the blood.

Fig. 2, however, shows that when total rather than partial equilibrium is considered the maximum of carbamino concentration is reached at Pco_2 0.1 mm Hg and at a very alkaline pH. Moreover, it is only 13 per cent. of the base concentration. At higher Pco_2 the curve falls off sharply and at Pco_2 50 mm Hg the carbamino concentration is low and *decreases,* but only by a trifling amount, as the Pco_2 is increased. Moreover, it can be easily shown that at pH < 8 the carbamino-CO_2 is only a small part (< 3 per cent.) of the total CO_2.

It is this total equilibrium state which corresponds to that of the blood under physiological conditions. If hemoglobin behaves similarly to amino-acids, the rôle of carbamino-hemoglobin as a carrier of CO_2 appears to be relatively insignificant.

In addition it must be remembered that carbonic anhydrase, a specific enzyme, enormously accelerates reaction 2 as has been shown by Meldrum and Roughton[6] and by Stadie and O'Brien.[7] Thus the discrepancy between the velocities of the two reactions is wiped out and the possibility of the occurrence of an equilibrium of the first type vanishes. This again emphasizes the necessity of considering only equilibrium 2 as being significant in the problem of the CO_2 transport by the blood.

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REFRACTORINESS TO OVARIAN STIMULATION IN THE RHESUS MONKEY

IN a series of publications Cole and Hart[1,2,3] and their collaborators have described the presence, quantity and biological activity of a gonadotropic substance in the blood serum of pregnant mares. Evans, Gustus and Simpson[4] have published a method for the purification and concentration of this gonadotropic substance and have also described its effects on the gonads of male and female rats.

[6] N. U. Meldrum and F. J. W. Roughton, *Jour. Physiol.*, 80: 113, 1933.

[7] W. C. Stadie and H. O'Brien, *Jour. Biol. Chem.*, 1933, 100: lxxxviii, 1933; *Jour. Biol. Chem.*, 103: 521, 1933.

[1] H. H. Cole and G. H. Hart, *Amer. Jour. Physiol.*, 93: 57, 1930.

[2] H. H. Cole and G. H. Hart, *Amer. Jour. Physiol.*, 94: 597, 1930.

[3] H. Goss and H. H. Cole, *Endocrinology*, 15: 214, 1931.

[4] H. M. Evans, E. L. Gustus and M. E. Simpson, *Jour. Exp. Med.*, 58: 569, 1933.

Since this substance manifests biological activity similar to extracts of the anterior pituitary gland containing gonadotropic hormones, it became of interest to determine its effect on the ovaries of immature rhesus monkeys.

Each of five immature monkeys weighing between 2,100 and 2,500 grams was injected daily with 5 r. u.[5] of the gonad-stimulating hormone purified by the method of Evans, Gustus and Simpson. The periods of injection varied from forty-five to seventy days. (Some of the monkeys are being injected as this report is being written.) Two of five monkeys were injected intravenously and the others subcutaneously. Reddening and swelling of the sexual skin (which occurred on the fourth to tenth day after the first injection) were the first indications that the hormone injected was stimulating the ovaries. The maximal development of the sexual skin was reached on the thirteenth to twentieth days of the injection period and had returned to interval or castrate type by the twenty-seventh to fortieth days.

The ovaries were examined and measured at intervals and it was found that very great follicular development had occurred as early as the ninth to twelfth days. The size of the ovaries at this time varied in different monkeys, but the average dimensions were of the order of $14 \times 12 \times 7$ mm. There was no evidence at any time that corpora lutea had been produced or that ovulation had taken place. Examination of the ovaries at the thirty-eighth to fortieth days of the injection period showed that they had decreased in size, and in two cases the regression was such that they were of infantile dimensions. Such ovaries were white, shrunken structures which did not show any evidence of the many large follicles which had been present earlier.

Vaginal lavages were taken daily and a study of these showed that there was an early increase in the number of epithelial and cornified cells with a decrease in the number of leucocytes. As the injections were continued, the leucocytes increased in number and the cornified cells gradually disappeared.

The decrease in the number of cornified cells and regression of the sexual skin were followed by menstruation in all the monkeys. The occurrence of this phenomenon varied between the fifteenth and thirty-second days of treatment. Menstruation was observed eighty-seven days after the last injection in one of two monkeys which had been injected for fifty-four days. The other monkey began to menstruate on the forty-eighth and again on the eighty-second day after the treatment had been stopped.

[5] A rat unit is defined as the total amount of hormone which, when administered in daily doses of one cc for three days to immature female rats, causes an increase of approximately 500 per cent. in weight of ovaries ninety-six hours after the first injection.

We conclude from these data that the ovaries of immature monkeys are first greatly stimulated by the gonadotropic hormone of pregnant mare's serum, but later and during the chronic administration of the hormone they regress to a relatively infantile condition.

Zondek[6] has reported that the ovaries of mice which have received chronic treatment with a gonadotropic extract of pregnancy urine first show a great increase in weight, but that after a certain time the weight was normal, although the administration of the extract had been continued. Collip and his co-workers[7] have reported the same results for rats which have received hypophyseal implants for many days or have been subjected to chronic treatment with placental extracts. They[8] have also demonstrated that the blood of rats injected with placental extracts for many weeks inhibits the ovary-stimulating effect of such extracts when tested in the immature female rat.

We have tested the serum of our monkeys for such an inhibitory effect against the gonad-stimulating hormone of pregnant mare's serum. If it is present at all in the serum of monkeys before injections were begun, it is there in relatively small amounts, since one cc of monkey serum does not inhibit the ovary-stimulating effect of the hormone when tested in immature female rats twenty-one to twenty-three days of age.[9] However, the blood serum acquired an inhibitory action as the injections of the hormone were continued. A definite inhibitory effect was obtained with one cc of serum as early as the twenty-seventh day of the injection period, and continued administration of the hormone caused the antagonistic effect to become greater. Thus after thirty-nine days of injections as little as 0.025 cc of monkey serum per day for five days was sufficient to completely prevent the gonad-stimulating effect of one rat unit of mare serum hormone. However, the usual amount required at this time was 0.05 to 0.10 cc per day.

A very definite inhibition of the action of the mare serum hormone has been obtained with serum obtained from a monkey sixty-seven days after the injections of the hormone had been stopped.

The antagonistic action of the monkey serum exhibits considerable specificity, as evidenced by the fact that the serum did not demonstrate an inhibitory

[6] Cited by J. B. Collip.[7]

[7] J. B. Collip, *Jour. Mt. Sinai Hospital*, 1: 28, 1934.

[8] H. Selye, C. Bachman, D. L. Thomson and J. B. Collip, *Proc. Soc. Exp. Biol. Med.*, 31: 1113, 1934.

[9] The method of testing for the antagonistic effect consists of injecting $\times$ cc of monkey serum per day for five days and one third of a rat unit of gonadotropic hormone per day for the last three of the five days that the monkey serum is being injected. The rats are killed 144 hours after the first injection of monkey serum and the ovarian weights compared with those of control animals which have received only one third of a rat unit of the gonadotropic hormone per day for three days.

effect toward the gonad-stimulating action of human pregnancy urine, whole sheep pituitary gland and whole human pituitary gland extracts, when tested in the immature female rat.

Thus an apparent refractory condition of the ovaries of immature monkeys to the gonadotropic hormone of pregnant mare's serum has been produced by chronic treatment with the purified hormone. We believe this condition is related to the presence in the serum of the monkeys of a substance which prevents the action of the gonad-stimulating hormone.

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THE CONTROL OF BRONCHIAL ASTHMA[1]

IN fifty cases of bronchial asthma the attacks of paroxysmal dyspnea have been prevented by a régime of treatment based upon elimination, by postural drainage, of the accompanying bronchial and pulmonary exudate.

It is our conception that the fundamental pathological change in bronchial asthma is chronic, nontuberculous pulmonary infection with characteristic[2] hypertrophic and inflammatory change in the lymphoid tissue, thickening and hyalinization of the bronchial and bronchiolar basement membrane, sacculation and ulceration of the bronchial mucosa with marked cellular infiltration. The products of this infectious process are the causative factors in the provocation of the asthmatic attack. When these products are not permitted to accumulate in the bronchii and lungs the asthmatic attack never occurs.

The first therapeutic step is reduction of the viscidity of the bronchial and pulmonary exudate in order to facilitate its evacuation. For this purpose elixir of terpene hydrate, guiacol, sodium iodide, potassium iodide, ammonium chloride and compound tincture of benzoin by steam inhalation have been used singly or in combination.

After the viscidity of the exudate is reduced the patient is instructed to kneel on a chair or stool and place both hands on the floor. The more nearly the thorax approximates an inverted vertical position the more nearly ideal are the results. Compromise positions can be devised for the enfeebled patient. While in this position the patient coughs as nearly continuously as possible and peroral drainage of the exudate is thus accomplished through the combined agencies of the tussive squeeze, ciliary drainage and the bechic blast.[3] The exudate is then expectorated. The inverted position is maintained for a minimum of three minutes regardless of productivity. This procedure is carried out at least twice daily, preferably on arising and retiring. Coughing during the interval between drainage procedures is the signal that insufficient evacuation of the bronchial passages has been accomplished, and the frequency of the drainage procedure is then increased.

The clinical and autopsy evidence available indicates that sinusitis, tonsillitis and possibly dental abscess are highly important factors in the production and perpetuation of the inflammatory bronchial and peribronchial process resulting in paroxysmal dyspnea. It seems probable that although such focal infections are extremely common they are productive of bronchial asthma only when constitutional thymicolymphatic stigmata are present.

Although it is possible by the above procedure to prevent asthmatic attacks where active infectious foci are present, total and permanent quiescence of the bronchial and peribronchial inflammation will occur only after ablation of these foci. Under this treatment régime the laboratory and physical signs of bronchial asthma disappear. Some of our patients have been asymptomatic for four years without treatment.

Our series consists of a group of severe and recalcitrant cases ranging in age from six to seventy-five years. Strict adherence to the régime has not yet failed to keep our patients free from asthmatic attacks.

Further studies are in progress regarding other factors which appear important in the provocation of the asthmatic attack and in the perpetuation of the disease process.

NOEL F. SHAMBAUGH[4]
SAM M. ALTER

[1] Preliminary report.

[2] Ian G. Macdonald, *Annals of Internal Medicine*, vi: 253, 1932.

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[4] From the Department of Internal Medicine, University of Southern California.

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